SCIENCE ABSTRACTS.

Section A.—PHYSICS.

SEPTEMBER 1918.

GENERAL PHYSICS.

883. *Hot-wire Vacuum Gauge with Multiplier.* **W. Tschudy.** (Elekt. Zeits. 39. pp. 235–237, June 13, 1918.)—A brief description is first given of the hot-wire vacuum gauges of Hale, Schäfer, and Kohlrausch and then a new type is described. For the latter a suitable hot-wire is found in the filament of a 10-watt lamp, the current through which actuates a shunted galvanometer. A 100-ohm resistance is connected between one of the battery terminals and one side of the galvanometer, the other battery terminal being connected to the bar of the galvanometer shunt. The galvanometer, provided with one or more scales, is calibrated to read the degree of vacuum direct, and the scale readings depend on which of the three shunt plugs is inserted. The resistances are adjusted so that the scale readings are in the ratio 1 : 2 : 3. The calibration of the apparatus is effected by the aid of a McLeod gauge.
A. W.

884. *Analysis of Periodic Curves.* **H. Weiss.** (Soc. Int. Élect., Bull. 8. pp. 259–277, June, 1918.)—Gives a detailed comparison of the methods of curve analysis of L. Hermann and S. P. Thompson. It appears that the two methods are essentially but two different methods of carrying out the same mathematical process, and the question as to which method is the more practical depends on the particular curve to be analysed. A. W.

885. *Strength of Laterally Supported Beams.* **H. Kayser.** (Zeits. Vereines Deutsch. Ing. 62. pp. 382–387, June 22, 1918.)—A theoretical investigation of the conditions governing the failure of beams with elastic lateral support. With a high value of the supporting force it is found that the strength of a beam with free ends approaches that of a beam with fixed ends. A curve is given for the determination of the ratio between the actual strength of a beam and the value given by the Euler formula under various conditions as to the ratio between the lateral supporting force and the function π^2EI/l^2. J. W. T. W.

886. *Determination of Hardness of Metals by Impact.* **C. A. Edwards** and **F. W. Willis.** (Inst. Mech. Eng., J. 5. pp. 335–369, June, 1918.)—Use is made of an impact device whereby a known amount of energy is imparted to a hammer and the blow then transmitted through a 10-mm. ball on to

the surface under test. The hardness of the material is estimated by measurement of the diam. of the impression produced. The apparatus used is described and is capable of imparting impact energies varying from 1¾ to 147 inch-pounds. Reliable hardness tests can be made in this manner and the results obtained can be converted into terms of Brinell hardness-numbers. Results indicate that there is a law governing the resistance to penetration of metals which are capable of plastic deformation. This law may be expressed by the equation $d = CE^{0{\cdot}25}$, where d is the diam. of the indent made by a 10-mm. ball, C is a constant which varies with the hardness of the metal, and E is the total energy of impact. By using the factor C for any particular metal and the above equation for calculating the energy of impact required to give an indent of standard dimensions, a new hardness scale in inch-pounds impact energy is obtained which is regular throughout its length. By using the impact method or scale, the two factors time and degree of deformation, which have different effects with materials of varying hardness, are eliminated. The effect of these two factors renders the Brinell scale unsatisfactory.

The method of estimating hardness by the rebound of a hammer after falling from a fixed height is unreliable. It would appear that this method would give a regular scale, only if the energy of impact were so adjusted that the same amount of penetration is obtained in all tests. C. O. B.

887. *Elastic Indentation of Steel Balls under Pressure.* **C. A. Briggs, W. C. Chapin, and H. G. Heil.** (Am. Soc. Mech. Eng., J. 40. pp. 386–388, May, 1918.)—The area of contact made by flat and spherical surfaces held together by varying pressures has been measured by viewing it as the central spot in the Newton's ring system formed when a glass surface was in contact with polished steel or another glass surface. A max. pressure of 20 lbs. was used on ¾-in. and 1-in. diameter balls and on smaller balls correspondingly lower pressures were employed. All possible combinations of flat and spherical surfaces of steel and glass were used except steel and steel. Examination of the results indicates that the indentation is not a linear function of the pressures, but is proportional to the two-thirds power of the pressures. In the equations given below dG is the mutual indentation between the surfaces in contact, P the pressure acting between the two surfaces, G_1 and G_2 the radii of curvature of the two surfaces and E_1' and E_2' the indentation moduli of the surfaces G_1 and G_2. Hertz has shown theoretically that the elastic property determining indentation is a function of Young's modulus (E) and Poisson's ratio (U) given by the equation $E' = E/(1 - u^2)$ and he called the quantity E′, the indentation modulus.

General equation for indentation :—

$$dG = 0{\cdot}518 \left\{ P^2 [(G_1 + G_2)/G_1G_2] [1/E_1' + 1/E_2']^2 \right\}^{1/3}$$

Indentation of steel balls between flat steel surfaces :—

$$2dG = 0{\cdot}0021 \, (P^2/G)^{1/3}$$

Diameter of area of contact between steel and steel surfaces :—

$$R = 0{\cdot}0647 \, (PG)^{1/3}$$

Average pressure over areas of contact :—

$$S = 304 \, (P/G^2)^{1/3} ;$$

all the quantities being in metric units. F. C. A. H. L.

888. *The Relationship of Impact Value to Maximum Stress, Elongation, and Brinell Hardness.* **G. Berndt.** (Zeits. Vereines Deutsch. Ing. 62. pp. 421–422, July 6, 1918.)—The impact value was measured of some 40 samples of basic Siemens steels of which the elastic limit, max. stress, percentage elongation, and Brinell hardness were all known. With the exception of the elongation these values at first increased as the impact value rose, reaching a maximum with an impact value of 1·3 kg.-m., after which they decreased rapidly and became finally more or less stationary. The impact value, which is of all the properties measured the most sensitive in detecting brittleness, appears to increase with the ferrite content of the steel. Two photomicrographs are included. F. C. T.

889. *Failure of Ductile Materials under Fluctuating Compound Stresses.* **H. A. Webb** and **W. H. Barling.** (Aeronautics, 14. pp. 331–333, April 17, 1918. Am. Soc. Mech. Eng., J. 40. pp. 584–585, July, 1918. Abstract.)—Gives a summary of previous work on the subject, and develops an empirical equation based on the analogy of the equation for ductile materials under fluctuating direct stresses, namely: $P = 2p_1/(1 + p_2/2p_1)$, where P is the equivalent static stress, and p_1 and p_2 the maximum and minimum stresses respectively. This new equation is $S = 2s_1(1 + s_2/2s_1)$, where s_1 and s_2 are the maximum and minimum shear stresses (s_2 may be negative) at a given point, in a given plane through that point, and S is the equivalent static shear stress at the same point in that plane. The application of this formula to the case of a crankshaft of an aero engine, where the shaft is subjected at any given section to a fluctuating direct stress p, due to bending and thrust, and a fluctuating shear stress q, due to torque, is worked out in full in the paper. J. W. T. W.

890. *Critical Loading of Struts and Structures.* **W. L. Cowley** and **H. Levy.** (Roy. Soc., Proc. 94. pp. 405–422, June 1, 1918.)—The main points of practical importance in the following paper are:—

(*a*) Discussion of stability of a prismatic homogeneous strut on simple supports, loaded laterally and longitudinally—criterion for failure.

(*b*) Equation of three moments generalised to include the case where the central axis is constrained to pass through $n+1$ non-collinear points, and where lateral loading and longitudinal end thrusts exist.

(*c*) Application to the case of n bays, and the calculation of the moments, reactions, etc.

(*d*) Case where one or more bays of Euler's critical length are present in the system. It is here shown that in general failure does not result.

(*e*) Failure will not in general take place if $n-1$ bays are of Euler's critical length, and the remaining one less.

(*f*) Case where one or more bays are twice Euler's critical length.

(*g*) General condition of failure for a structure of n-bays.

(*h*) Conditions of strengthening or weakening by the addition of an extra bay to a structure critically loaded.

(*k*) Extension of the previous work to include the external loading due to wires in tension attached to the beam in the region of the supports.

(*l*) Clamped supports:—Determination of bending moments, etc., and condition of failure.

(*m*) Strengthening effect of clamped supports. L. H. W.

891. *Experimental Determination of Moments of Inertia of the Form $Xd\theta/dt$.* **A. Guillet.** (Comptes Rendus, 166. pp. 33–35, Jan. 7, 1918.)—A galvanometer, the moving system of which is acted on by a couple of moment $gi\cos\theta$ when deflected by a current i through an angle θ, is inserted in a circuit of negligible self-induction and of resistance R. Then, for small deflections, the equation of motion will be $\mathrm{I}d^2\theta/dt^2 + g^2/\mathrm{R}\,.\,d\theta/dt + \mathrm{C}\theta = 0$. A moment proportional to $d\theta/dt$ is then introduced, which may be varied by varying $b = g^2/\mathrm{R}$, within the extreme limits g_0^2/R_0 and g_1^2/R_1, depending on the moving system. Then, if b_0 and b_1 are the values of b which give the same deflection with and without the unknown moment $\mathrm{X}d\theta/dt$, the value of X will be $b_1 - b_0$. The author shows how such questions as the variation in the viscosity of a liquid with the temperature may be investigated in this manner. G. W. DE T.

892. *The Non-molecular Structure of Solids.* **A. H. Compton.** (Frank. Inst., J. 185. pp. 745–774, June, 1918.)—It has been shown by W. H. and W. L. Bragg [Abs. 876 (1914)] from an examination of X-ray spectra, that the arrangement of atoms in certain crystals indicates that in these crystals there is no molecular structure, but that the whole mass is a homogeneous bundle of atoms which have no tendency to form molecules. The author now puts forward, and supports, the thesis that "every atom in a solid has its position so determined by the other atoms that it cannot be said definitely to belong or not to belong to the same molecule as some other atom." The author points out from the dependence of crystal form on chemical composition, from a consideration of the Dulong-Petit law and of the nature of cohesion, and from the evidence of X-rays as to certain crystals, that each atom in a solid oscillates about a definite position of stable equilibrium. From a further examination of the nature of cohesion and of the forces concerned in chemical combination, and especially from the general relation found between the atomic heat of formation of a substance and its melting-point, it is found that the forces holding the atoms in their positions of stable equilibrium are of the same nature and comparable in magnitude with the forces binding together a chemical molecule. It is seen further that the atoms in a solid are very close together, so that they often come into contact. And, since an atom attracts equally all atoms of another kind which are in contact with it, an atom cannot remain combined for more than an infinitesimal interval with any other particular atom at ordinary temperatures. Finally, it is shown that, since in the solid state each atom has three degrees of translational freedom and is strongly attracted by atoms other than those of its own "molecule," it must, on the average, exert equal attractions on all the neighbouring atoms. From this the conclusion is drawn that in the solid state the atoms are so intimately intermingled that particular molecules cannot be definitely defined. When those properties of solid matter which have been explained by molecules are considered, nothing is found which indicates at all definitely a molecular structure. The author therefore concludes that the structure of solid matter is not molecular. A. F.

893. *The Principles of Diffusion, their Analogies and Applications.* **H. T. Brown.** (Chem. Soc. J., Trans. 113. pp. 559–585, July, 1918.)—In this lecture, delivered before the Chemical Society, the author reviews his work on diffusion. Fick's law, deduced on the analogy of Fourier's law of the flow of heat, has been found to be a very good approximation, and sufficient for all ordinary purposes. But diffusive flow is also analogous to the steady flow of electricity along a conductor of uniform cross-section, maintained at its two ends at a constant p.d., and a number of experiments are quoted which illustrate, in a remarkable manner, this analogy. Moreover, the phenomena

of steady diffusion around a sphere are strictly analogous to those exhibited by a freely suspended and insulated spherical conductor which is electrically charged. These analogies can be clearly represented by diffusion through gels. It is also pointed out that from a mathematical analysis, not yet complete, it appears that if a small elongated body which has a differential power of absorption at its two ends is introduced into a diffusive flow, it will tend to set itself along the lines of flux and to head up-stream with its less absorptive end facing the region of higher concentration of the diffusate. If this deduction is correct, the author sees in it a physical explanation of certain phenomena of chemotaxis.

The phenomenon of gaseous diffusion is of great importance in connection with the passage of carbon dioxide through the stomata of plant leaves. Just as the electric capacity of a plate is not considerably affected by cutting parts of it away and leaving an open framework, so also it is possible to block out a considerable portion of the cross-section of a diffusive column without materially altering the general static condition on which the flow depends. Herein is found the explanation of the effectiveness of the stomata of a green leaf. Probably the same effectiveness is shown by the stigmata of certain animals whereby it becomes possible for the animal, in the resting state, to carry on its respiration entirely by diffusion along the ramifying tracheæ which communicate with the outer air through the stigmatic openings in the skin. A. F.

894. *Variably-coupled Vibrations.* III. *Both Masses and Periods Unequal.* **E. H. Barton and H. M[ary] Browning.** (Phil. Mag. 36. pp. 36–47, July, 1918.)—The mechanical case here dealt with may be regarded as somewhat analogous to the electrical case of coupled circuits in which the self-inductions and periods are both unequal.

Photographs were taken (reproduced in original article) from sand traces obtained when the masses were 20 : 1 and the respective lengths as 4 : 3, also with lengths as 9 : 8, in each case the lighter bob being on the shorter pendulum. Afterwards cases were studied with pendulum lengths as 3 : 4, the masses of bobs being still 20 : 1, but the *heavy* bob being now on the *short* pendulum.

The results of theory and experiment were striking. The ratio of the frequencies of the separate pendulums slightly exceeds 8 : 7. As the coupling was increased from 1 to about 6 per cent., the ratio of the superposed coupled vibrations *diminished* to about 13 : 12, and the two pendulums had distinctly greater action and reaction on one another. When the coupling was further increased, the ratio of superposed frequencies increased and reached 2 : 1 for a coupling of about 30 per cent. The special features of this case with a short heavy pendulum coupled to a long light one are illustrated by graphs and a number of photographs of sand traces.

J. A. Fleming has pointed out that by means of a rapidly damped spark discharge in a primary circuit, a slowly damped electrical vibration may be produced in the secondary or antenna. In this paper a photograph of a mechanical analogue of such a discharge is reproduced from a sand trace. To obtain this effect the masses of the bobs were made equal and also the lengths of their suspensions; the coupling was about 10 per cent. One of the bobs was drawn aside and the other allowed to hang at rest. The other bob was then let go, and its oscillations were quickly diminished by the transference of its energy to the other pendulum which, in about six vibrations, had attained an amplitude equal to that with which the other pendulum started. The first pendulum had at this instant lost all amplitude, and it was suddenly raised by hand and held still. The other bob then retained the full amplitude it had acquired, thus representing the oscillation in the antenna. A description is given of a portable apparatus for demonstration of these coupled pendulums, vibrations, etc., and various lines of further work are sketched out in conclusion. [See Abs. 1221) 1917) and 335 (1918).] E. H. B.

895. *Ultramicroscopic Investigation of very Thin Metal Films obtained by Evaporation in a High Vacuum.* II. **W. Reinders** and **L. Hamburger.** (K. Akad. Amsterdam, Proc. 20. 8. pp. 1135–1154, 1918.)—This is a continuation of previous investigations [Abs. 1375 (1917)], a method being here described by which the metal films can be protected by films of either calcium fluoride or Canada balsam or both whilst still in a vacuum. The elements investigated were W, Mo, Pt, Fe, Ni, Au, Cu, Ag, Mg, Zn, Cd, and C. The elements of high melting-point, W, C, Mo, Pt, Ni, and Fe, give films which are optically either completely non-resolvable (W, C, Pt, and Fe), or for the most part non-resolvable with another part containing distinctly separate particles. The elements of lower melting-point, Au, Ag, Cu, Mg, Zn, and Cd, show a far greater tendency to give a film consisting of a connected network of ultra-microns. The conclusion is drawn that in proportion as the temperature of incandescence required for slow sublimation is higher, the finer the structure of the sublimate (film) formed. Experiments in which the temperature of the glass on which the film was deposited was varied, showed that the greater the vapour pressure of the metal at the temperature of the glass on which it is deposited, the coarser is the structure of the deposit. Various grades of coarseness can be observed, varying from deposits which are optically non-resolvable to deposits on which the smaller particles are distinctly separate.

W, Mo, C, Fe, Ni, and Pt give colourless films, whereas the other elements give coloured films which, in the case of Ag, Au, and Cu, may show a great wealth of colour. The colour does not depend directly on the structure of the metal. For example, Au, Ag, and Cu show the same sequence of colours in mosaic deposits formed at room temperatures as in the structureless deposits formed at the temperature of liquid air. No colouring sets in with Pt, W, and Fe when the structureless deposit is transformed into a mosaic deposit by local heating. The conclusion is drawn that the capacity for displaying colour is an individual property of the metal and is determined by the selective absorption of the atoms. T. S. P.

896. *Internal Ballistics.* **A. G. Hadcock.** (Roy. Soc., Proc. 94. pp. 479–509, July 1, 1918.)—The object of the author is to explain and illustrate a method he has devised for obtaining the pressure-volume relation of the gases in the bore of a gun, from the instant of ignition of the charge to the instant when the shot leaves the gun. By the aid of expressions given in the paper, the pressure-volume curve, or the indicator diagram, of the charge can be plotted when the nature and weight of charge is given. The peculiarity of this problem compared with similar problems of all kinds of internal-combustion engines other than the gun, is that energy is produced in the gun by the burning of solid fuel within the gun itself during a considerable fraction of the expansion stroke. In other internal-combustion engines, energy is added to the charge by combustion of the charge almost at constant

volume, and no account need be taken of the rate of combustion of the fuel. In the gun problem, the rate at which the charge is burnt, that is, the rate at which energy is produced, is fundamental to any investigation of the subject. There is the additional complexity that a discontinuity exists in the expansion of the gases at the point where the charge is just burnt. Up to this point expansion proceeds with the continuous addition of energy from the burning charge: after this point expansion proceeds nearly adiabatically. The influence of the resistance of the driving band on the subsequent expansion of the gases, and on the max. pressure produced by the charge, is another vital element in the problem. The author has chosen to use the pressure-volume equation for the expansion of the gas of the general form $p[(v-a)/z]^{\epsilon} = k$, a constant, because its constant can be more easily adjusted to meet the conditions found from experiments than with other methods; p is the pressure, v the volume, z the fraction of the charge burnt, and a is a constant called the co-volume.

Section 2 deals with the rate of burning of the charge. Recent work on this subject is discussed in conjunction with the author's own research. In Section 3 the equation of expansion is derived. Section 4 considers expansion curves for different values of z, while Section 5 deals with the pressure equation and the variation of the constant k. The initial resistance, during engraving, of the copper driving band, which is fitted to the projectile to give rotation, plays a most important part in the development of both the gas pressure and the velocity of the shot. The greater this initial resistance is, the earlier the max. chamber pressure will be attained, and the higher will be this pressure and the muzzle velocity. Section 6 investigates the instantaneous mean pressure in the gun. Here the author considers it reasonable to assume that the pressure in the bore falls more or less regularly from the breech to the base of the shot, and that the mean rate of burning of the explosive is that due to the mean pressure in the bore. Section 7 considers the motion of the shot. Tables are given for cylindrical cordite and tubular powder. Section 8 develops an expression for the max. pressure. In Section 9 the resistance of the driving band is considered at some length. The resistance begins with a fairly rapid rise, and the curve usually takes a parabolic form; it then flattens, and when about two-thirds of the band is engraved, the resistance gradually falls until the engraving is completed. The curve then runs nearly parallel to the datum line. Section 10 completes the paper with values of the various functions and numerous examples. The paper is illustrated by several sets of curves and diagrams. H. H. Ho.

897. *Principal Points of the General Theory of Relativity.* **A. Einstein.** (Ann. d. Physik, 55. 4. pp. 241–244, May 24, 1918.)—A series of recent publications, in particular a critical one by Kretschmann [see Abs. 457 (1918)], have induced the author to state once more the fundamental features of the general theory of relativity. The latter rests upon three main hypotheses, which, however, are not independent of each other, namely: (*a*) The Relativity Principle, by which natural laws are only statements of time-space coincidences and find a single natural expression in general covariant equations. (*b*) The Principle of Equivalence by which inertia and weight are essentially equal. From this principle and from the results of the special theory of relativity it necessarily follows that the symmetrical fundamental tensor $g_{\mu\nu}$ determines the metrical properties of space, the inertia behaviour of bodies in it, and the gravitational effects. The space condition given by the fundamental tensor is designated as the G-field. (*c*) Mach's Principle by which the G-field is determined without residue by the masses of the bodies. Since mass and energy are the same according to the conclusions of the special relativity theory and the energy is formally described by the symmetrical energy tensor $T_{\mu\nu}$, it follows that the G-field is determined by the energy tensor of matter. With respect to (*a*) Kretschmann remarks that the so-formulated relativity principle is no expression of physical reality, *i.e.* of the natural laws, but only an assistance towards mathematical formulation. Since, however, the whole physical experience only rests upon coincidences, it should always be possible to obtain a regular connection of these coincidences by general covariant equations. Kretschmann deems it necessary to connect another idea with the relativity hypothesis.

The present author while endorsing Kretschmann's argument does not, however, recommend his proposals. If it is correct that every empirical law must be brought into general covariant form, then the principle (*a*) possesses a significant heuristic force which is exceedingly valuable for the gravitational problem. Principle (*b*) has formed the starting point of the whole theory and brought about the existence of Principle (*a*). It cannot be omitted so long as the fundamental ideas of the theoretical system are maintained. It is otherwise with Mach's Principle, although the author claims its acceptance as absolutely necessary—and, in the present paper, puts forward his reasons. This third Principle determines the space-time structure of the universe, and the author concludes that its geometrical shape deviates only slightly from that of a spherical (*i.e.* elliptical) space, and that only locally, *e.g.* as the shape of the earth's surface differs from that of an ellipsoid. H. H. Ho.

898. *Generalised Relativity and Gravitation.* **E. Woolard.** (Am. J. Sci. 45. pp. 425–487, June, 1918.)—A semi-popular *résumé* of relativity from Newton to the present time with references to the works and papers of Michelson and Morley, Minkowski, Lorentz, Einstein, and de Sitter.

E. H. B.

899. *Cohesion.* IV. **H. Chatley.** (Phys. Soc., Proc. 30. pp. 151–156; Disc., 156. April, 1918.)—The aim of this paper is to consider the value of molecular force as indicated by van der Waals' gas formula (particularly at the critical state where the liquid and gaseous states merge), and to relate the results to the previous enquiry. In the *discussion*, **H. S. Allen** doubted whether any attempt to found a theory on purely central attractions and repulsions varying as some power of the distance could prove adequate to explain the facts. Reference was made to the work of W. Sutherland on molecular theory and also to the probability that the forces of cohesion between the particles which give a solid its rigidity are electrical forces.

E. H. B.

900. *Wave Propagation and Einstein's Gravitation Theory.* **E. Vessiot.** (Comptes Rendus, 166. pp. 349–351, Feb. 25, 1918.)—The author here applies the mathematical results of his investigations into the general theory of wave propagation [Bull. Soc. Math. 34. p. 230, 1906; and Ann. Sci. de l'École Normale Sup. 3^e Sér. 26. p. 405, 1909] to Einstein's gravitation theory, leading to the following conclusions:—Light, in Einstein's theory, is propagated by waves satisfying the laws of Huyghens and Fermat. The partial differential equation of a family of waves is obtained by equating to zero the differential parameter $\Delta_1 f$ of Beltrami: Given the wave surfaces, the gravitation field is completely definable in terms of the single quantity $\sqrt{-g}$, where g is the discriminant of the author's fundamental equation of wave motion: The motion even of material points may be represented as a permanent wave-motion in the Minkowski time-space: Luminous, electromagnetic, and gravitational waves are propagated in accordance with the same law, so that there is no inconsistency between the electromagnetic theory of light and Einstein's theory. G. W. DE T.

901. *System of Reference for Absolute Motion.* **P. Appell.** (Comptes Rendus, 166. pp. 513–516, April 2, 1918.)—The author shows that given any system S of moving particles, it is always possible, according to Newtonian dynamics, to determine theoretically a fixed system T with a point coinciding with the mass-centre of S such that the vector sum of the momenta of S relative to T vanish, so that the motion of S relative to T will be identical with its absolute motion, and T may therefore be regarded as a system of reference fixed in space. If then S be taken as representing the entire universe, T may be regarded as a system of reference for which Newtonian dynamics will, in all probability, apply with sensible exactness to the universe. G. W. DE T.

902. *On Ship-waves, and on Waves in Deep Water due to the Motion of Submerged Bodies.* **G. Green.** (Phil. Mag. 36. pp. 48–63, July, 1918.)—A mathematical treatment which should be consulted in the original.

L. H. W.

903. *A Century's Progress in Physics.* **L. Page.** (Am. J. Sci. 46. pp. 303–354, July, 1918.)

904. *Problems in Atomic Structure.* **J. J. Thomson.** (Engineering, 105. pp. 206–208, Feb. 22; 234–235, March 1; 261–262, March 8; 286–288, March 15; 317–318, March 22, and pp. 344–346, March 29, 1918. Lectures delivered at the Roy. Inst.)—Sets forth in plain language certain of the problems now confronting physicists, the means and methods by which they are being attacked and the progress made towards satisfactory solution.

L. H. W.

905. *Gravitation and the Principle of Relativity.* **A. S. Eddington.** (Engineering, 105. pp. 153–154, Feb. 8, 1918. Discourse delivered at the Roy. Inst., Feb., 1918. Nature, 100. pp. 15–17, March 7, and pp. 3–36, March 14, 1918.)—A general non-mathematical exposition of the subject and the problems involved. L. H. W.

906. *The Energy Principle in the General Theory of Relativity.* **A. Einstein.** (Preuss. Akad. Wiss. Berlin, Ber. 24. pp. 448–459, 1918.)—Although the author's general theory of relativity has been accepted by the majority of theoretical physicists and mathematicians, yet objection [see Abs. 824 (1918)] has been taken to his formulation of the Impulse-Energy Principle. The author being convinced of the validity of this Principle examines the subject exhaustively in the present paper. In Section 1 the formulation of the Principle together with the objections raised against it are considered. Section 2 investigates how far energy and impulse are independent of the choice of coordinates. Section 3 evolves the Integral Principle for an enclosed universe. Section 4 deals with the energy of the spherical universe. In Section 5 the ponderous mass of a closed system is evaluated

and is found to be equal to the quantity which has been designated its energy. In a short appendix the author states that for the formulation of the Impulse-Energy Principle of a quasi-spherical (but not of a quasi-elliptical) universe, coordinates are to be preferred which are obtained by the stereographical projection of the sphere upon a (three-dimensional) hyperplane.

H. H. Ho.

907. *On the Formal Analogy between the Fundamental Electromagnetic Equations and Einstein's Gravitational Equations of First Approximation.* **H. Thirring.** (Phys. Zeits. 19. pp. 204–205, May 15, 1918.)—The present paper contains the development of an idea expressed in the footnote of an earlier communication [see Abs. 449 (1918)]. It concerns the analogy between the Maxwell-Lorentz equations, on the one hand, and those equations on the other which express point motion to a first approximation in a weak gravitational field. Einstein had already pointed out this analogy in 1913 [Abs. 395 (1914)], but since his field equations have more recently undergone very important modifications, it has become necessary to investigate the above analogy in the light of recent advance. The conclusion is drawn that the Maxwell-Lorentz equations are only approximate formulæ which, while sufficiently exact for electrotechnical purposes, require a corresponding generalisation for the much stronger fields concerned in atomic and electronic relationships. An outline of this modification has already been given by Hibbert and Mie.

H. H. Ho.

908. *Gravitation and Electricity.* **H. Weyl.** (Preuss. Akad. Wiss. Berlin, Ber. 26. pp. 465–480, 1918.)—The paper commences with a discussion of Riemann's views on geometry which according to him is based on two facts: (1) That space is a 3-dimensional continuum whose points may be evaluated in a continuous manner by a 3-coordinate system. (2) The Pythagorian hypothesis that the square of the distance ds^2 between two points infinitely close together, $P(x_1, x_2, x_3)$ and $P'(x_1 + dx_1$, etc.) is (by the use of any coordinates) a quadratic expression of the relative coordinates dx_i, namely: $ds^2 = \Sigma g_{ik} dx_i dx_k \, . \, (g_{ki} = g_{ik})$. The second fact may be briefly expressed: that space is a metric continuum. In the sense of modern physics the Pythagorian hypothesis is only valid at infinitesimal distances. The special relativity theory makes time a fourth coordinate equal in value to the 3 space coordinates, *i.e.* the material universe is a 4-dimensional metric continuum. This completely reverses the previous belief that space measure is independent of its material content. According to Einstein, therefore, the laws by which matter influences space-measure are none other than those of gravitation; that is, the g_{ik} form the components of the gravitational potential. While, however, the gravitational potential consists of an invariant quadratic differential, the electromagnetic phenomena are controlled by a 4-valued potential whose components ϕ_i unite to an invariant linear differential $\Sigma\phi_i dx_i$.

Both gravitation and electricity have hitherto been regarded entirely apart. Recent work by Levi-Civita, Hessenberg, and the author, shows that in order to develop Riemann's geometry in consonance with experience, the fundamental idea of the infinitesimal parallel displacement of a vector is necessary. This new infinitesimal geometry when applied to the universe, not only explains gravitational phenomena, but also those of the electromagnetic field. In general, therefore, gravitation and electricity can in nowise be separated. On this theory all physical quantities have a universal geometrical significance, and the activity principle can be expressed as a pure number. Definite world-laws can now be established, and in the paper the author develops this modified Riemann geometry. He finds that his theory leads to Maxwell's electromagnetic theory, but not to Einstein's gravitational equations. The author opines it to be very improbable that the latter are strictly valid. The paper concludes with a note by Einstein on the above theory and an answer by the author. [Abs. 605 (1918) should be consulted.] H. H. Ho.

909. *A Relative Theory of Gravitation from the Standpoint of Scalar Potential.* **J. Ishiwara.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 326–341, May, 1918.)—In an earlier publication the author sought to develop a relative theory of gravitation resting on the assumption that the change of velocity of light in space determines completely the state of the gravitational field. The transformation equations of the space-time coordinates in the original relativity theory have, however, been adopted in spite of the variability of light velocity, since their form remains unchanged, the idea of time being regarded as dependent upon the gravitational field. For length dimension in ordinary space this should not be the case. Such a space-time idea should be logically possible although in no way unique, but without experimental proof it could not be asserted that such actually held in Nature. Section 2 of the paper deals at some length with the transformation of space and time. Section 3 considers the equations of motion in the gravitational field. Section 4 investigates the fundamental equation, while Section 5 deals with the world tensor of the gravitational field. Section 6 investigates the perihelion motions of the planets. The author thus develops a scalar theory of gravitation based on the relativity principle. His theory is characterised by the following fundamental assumptions:—(1) The gravitational potential is completely determined by a scalar quantity ψ; the components g_{kk} of the fundamental tensor of the space-time transformation and the scalar vacuum light-velocity c are functions of ψ. It follows, therefore, that the field intensity is given by the gradients of ψ in the world space. (2) The dependence of g_{kk} and c upon ψ is shown. The former follows from the condition that the field equation takes the form of an extended Poisson equation. The latter postulates that the density of the gravitating mass no longer depends on the potential.

The theory evolved is shown to explain completely the observed perihelion motion of the planets. H. H. Ho.

910. *General Relativity without the Equivalence Hypothesis.* **L. Silberstein.** (Phil. Mag. 36. pp. 94–128, July, 1918.)—This paper deals with the subject in six sections. In 1 the purpose and scope of the inquiry is considered. The generalised theory of relativity as proposed by Einstein in 1912, and since that time repeatedly modified by himself and by his followers, has one very strong point, the requirement of general covariance of all physical laws, and one weak point, to wit: the originally so-called "equivalence hypothesis" which places gravitation on an entirely exceptional and privileged footing, bringing it into intimate connection with the fundamental tensor which appears in the line-element of this world. The author, in the present paper, proposes to retain the strong point and to reject the weak one, and thus develop the implications of the general principle of relativity without the equivalence hypothesis, *i.e.* without privileging gravitation at all. The scope of the paper will be limited, viz., to treat only some chief aspects

of the physical implications of the principle and to illustrate them to a certain extent, but by no means to try to embrace in a few generally covariant formulæ all the marvels of Nature. The strength of the "strong" point is indisputable and does not call for lengthy remarks; it amounts, in its ultimate analysis, to claiming that real, phenomenal contents should be expressed, or expressible at least, in a way showing their independence of the particular language or scaffolding adopted. The weakness of the "weak" point, however, does require some explanations. First of all, independently of agreement or disagreement with experimental facts, the equivalence hypothesis is a vulnerable point because of its very special nature and of the great number of assumptions which it tacitly implies. In the author's opinion, serious doubts with regard to its acceptability arise from the obstinately negative results recently obtained by St. John at the Mount Wilson Observatory on the displacement of the Fraunhofer lines. These are quoted at some length and well discussed. Another consequence of the theory, the bending of light rays by a gravitating mass, still awaits verification. Thus far the only positive success of Einstein's theory is the formula it gives without difficulty for the perihelion motion, but even this is most vitally conditioned by the tensor component g_{44} which has been discredited by St. John.

Section 2 deals with the space-time (world) of any constant curvature. Here the author rejects the gravitational "equivalence hypothesis," but retains the postulate of general covariance of physical laws. This phase he develops at great length, and, in Section 3, supports it by a mathematical supplement. Section 4 deals with natural systems of reference, the special problem being to find the generalisation of the Lorentz transformation for a space-time of any constant curvature. Expressions are deduced whereby the whole vector algebra for a non-homaloidal world may be developed. From this the author passes to physical laws endowed with covariance for any transformation of the four variables, and, in Section 5, deals with the fundamental electromagnetic vacuum-equations. Maxwell's equations are shown to occupy a unique position in General Relativity since they not only are generally covariant, but, unlike Einstein's recent products, possess the remarkable property of not being hitherto contradicted by any experiments or observations. In the concluding Section 6, the dynamics of a particle is discussed with the example of a covariant law of motion.

H. H. Ho.

911. *Mechanical Theories of the Electromagnetic Field.* VII. *The Basis of the Theory of Universal Oscillations.* **A. Korn.** (Phys. Zeits. 19. pp. 201–204, May 15, 1918.)—This paper is a mathematical dissertation on the structure of the ether. Into the latter, which is regarded as infinite in extent and incompressible towards oscillations of very short vibration frequency, particles are introduced which are capable of slight compression, *i.e.* mass systems which are able to undergo very small changes of density. The basic idea of the theory of universal oscillations rests upon the fact that every compressible system is capable of a series (in general infinite) of special oscillations. Now the infinite ether, with the slightly compressible particles orientated therein, is such a compressible system, and the special oscillations of this system are designated universal oscillations with the limitation that they are free from whirls. These feebly compressible particles, which are regarded as ponderable, are shown to follow the usual mechanical law of d'Alembert

in contrast to electrical particles. For the latter a term has to be introduced for their individuality [see Part I, Abs. 1071 (1917) and 88 (1918)]. Since the ether is the same towards universal oscillations as to electromagnetic phenomena, the author points out that the correction for individuality cannot change the form of motion of an incompressible medium free from whirls. The theory of universal oscillations will thereby remain uninfluenced by the correction for individuality and is so situated that the ordinary mechanical principle of d'Alembert has as strict validity for the ether as for the feebly compressible particles. On this account the author's previous statement of the theory of universal oscillations made in 1901, is shown to remain unaltered in form. The fundamental oscillations dealt with in the present paper point to the mechanical theory of gravitation. H. H. Ho.

912. *Mechanical Theories of the Electromagnetic Field.* VIII. *The Theory of Gravitation.* **A. Korn.** (Phys. Zeits. 19. pp. 234–237, June 1, 1918.)—This paper is a further application of the theory of universal oscillations [see Abs. 88, 186, 396 (1918) and preceding Abs.], in which feebly compressible particles are assumed to exist in an infinite incompressible ether, thereby bringing about special oscillations. The special case of the fundamental oscillation corresponding to the max. period is here examined, under the assumption that the feebly compressible particles in their mean position form a spherical surface whose radius has the same value for all the particles. A consequence of this fundamental oscillation is an apparent exchange effect between two particles of the system, which follows according to the Newtonian law of gravitation. This fundamental oscillation is found to be a pulsation of the feebly compressible particles, and the period of the pulsation varies directly as the radius. The case where other particles are introduced is considered and the solution found to vary only slightly from the simpler case when the radii of the particles are small in comparison with the central distance. A ponderable body is one in which such particles are present, and the mechanical theory of gravitation thus appears to suffice. Discussion of this standpoint is given at some length. H. H. Ho.

913. *Periodicity of Winter Temperatures in Western Europe.* **C. Easton.** (K. Akad. Amsterdam, Proc. 20. 8. pp. 1092–1107, 1918.)—All available data are collected and carefully sifted, reports of exceptionally mild winters being used in addition to those of severe ones. Each abnormal winter is given a coefficient of temperature ranging between +5 and −5, the remaining winters being marked zero. The series covers 1157 years. The data are investigated with a view to determining periodicities. An 89-year period is traced and it is further found that in the past 65 years, for which reliable thermometric observations are available, the temperature sequence of this 89-year period can be clearly followed, thus affording confirmation of its reality. The chief features of the fluctuation are that in the first quarter of the 89 years cold winters prevail and in the last quarter warm ones. A sine wave of 44½ years seems to be an important part of the 89-year fluctuation. It is considered that the results are sufficiently definite to be of some assistance in long-range forecasting. No evidence is found of a gradually increasing or decreasing frequency of severe winters in historical times.
J. S. Di.

914. *Dip-of-Horizon Measurements on the "Galilee" and "Carnegie,"* 1907–1917. **W. J. Peters.** (Terrest. Magn. 23. pp. 47–60, June, 1918.)—The dip of

the horizon, or the angle between the apparent horizon and the true level, is affected by refraction. Observers have sometimes reported this refraction effect as reaching so large a value as 10′ or 15′, the apparent horizon being raised by this amount from the position it would occupy if no refraction occurred. Such large values have not been found during the ocean cruises of the *Galilee* and *Carnegie*, the vessels engaged on the Magnetic Survey of the Carnegie Institution of Washington, though more than 3000 observations have been made. The greatest values recorded have been a raising of the horizon by 2·4′ and a depression of 2·0′. This does not prove that larger values may not occur in special localities, such as waters swept by very cold or warm land breezes. The instrument used was the Pulfrich dip-of-horizon measurer, which by a system of prisms brings the two opposite points of the horizon into the field of a low-power telescope and measures the difference between the vertical angle from horizon to horizon and 180°. Knowing the height of the point of observation above sea-level the refraction can then be calculated. Various sources of error are discussed. It has been put forward by some workers that the refraction effect on the dip is dependent on the difference of temperature between air and sea, and the following formula is tested from the present data: Refraction $= x + y \times$ (temperature difference, air — water), the most suitable values of x and y being determined. It is concluded that the value of y is inappreciable, that is, the temperature difference term is negligible over the open oceans to which these observations refer. The mean value of x is found to be $+0{\cdot}8'$ (horizon raised). Previous workers have in general found a smaller value of about 0·3′ or 0·4′. The height of the point of observation varied from 18 ft. on the *Carnegie* and 24 ft. on the *Galilee* to 30 ft. in some of the other cases quoted. It is pointed out that when aerial navigation across the oceans is realised some simple means of measuring the dip of the horizon will be very necessary. J. S. Di.

915. *Meteorology and War-flying*. **R. De C. Ward.** (Monthly Weather Rev. 45. pp. 591-600, Dec., 1917. Lecture given at the U.S. Army School of Military Aeronautics, Mass. Inst. of Technology.)—Deals with the subject under the following headings:—The atmosphere; Air currents above the surface in relation to aviation; Clouds; Weather forecasting; Favourable and unfavourable weather for flying. L. H. W.

916. *Dardanelles Earthquakes, Autumn* 1912. **M. Yélénko.** (Comptes Rendus, 166. pp. 784-786, May 13, 1918.)—Great shocks, followed by a suite of lesser tremblings, affected three areas centring round the Sea of Marmora —the principal being Eastern Thrace. Great destruction resulted, and earth movements, chiefly vertical, were observed to occur on a large scale. They were all tectonic movements along the two great faults of the Marmora basis, which has not yet attained equilibrium. The marked seismicity of the Balkan area is due to its being the junction of three great systems—the Dinaric Alps, the Carpatho-Balkans, and the broken Rhodope massif. W. A. R.

917. *Determination of the Second Derivatives of the Gravitational Potential on the Jaluit Atoll*. **M. Matsuyama.** (Kyōtō Coll. Sci., Mem. 3. pp. 17-68, Feb., 1918.)—In the introduction to this paper the Jaluit Atoll, which is situated at the southern end of the Ralick Chain of the Marshal Islands, is

described in detail. Among the scientific problems connected with coral atolls, the gravitational condition at such an isolated island of very simple construction is one of the most interesting, especially when the state of mass distribution under the atoll is considered. The present paper contains the records of an expedition made to the atoll in 1915, when the values of the second derivatives of the gravitational potential at various parts of the atoll were determined by the Eötvös gravity-variometer. Section II contains a detailed account of the instrument used; the principle of the instrument, the instrumental constants, the formulæ for calculation, and the correction of the error of azimuth being mathematically discussed. Section III contains the observation records in 18 tables. In Section IV these data are discussed at some length under the sub-headings:—Correction for the tidal effect; Reduction to a uniform set of coordinate axes; Correction for the effect of the neighbouring terrain; Correction for the ellipsoidal form of the geoid; Final values; Graphical representation with two illustrative plates.

For the determination of the second derivatives of the gravitational potential, three observations of equilibrium potentialare necessary which take some three hours. The surface-irregularities of the land in the neighbourhood of the stations are constant during this short interval, and their effect may afterwards be reduced if the necessary data are to be had. But the effect due to tidal disturbances is variable, even during this short interval and hence requires careful investigation. Section V deals with the depth of coral reef. Among the geodetic meanings, which the second derivatives of the gravitational potential contain, suggestions concerning the distribution of density under the ground are most interesting in the present case. Coral atolls are built naturally upon foundations that are probably of volcanic origin. The difference in density of the coral reef and the material of the foundation gives a means whereby to estimate the depth of the former. This is important whatever theory, subsidence or solution, is assumed concerning the formation of the atolls. For this purpose the values are first calculated of the second derivatives of the gravitational potential upon various assumptions as to the depth of the coral reef. The Jaluit Atoll has an irregular rhombic form difficult of mathematical treatment, so that the author has had to evolve a way for mechanical integration. Three tables of results accompany this section. Generally speaking, the gradients of the gravitational force on the atoll are directed inwards, perpendicular to the line of the reef. The curvature of the equipotential surface is larger in the direction perpendicular to the line of the reef than in the direction parallel to it. The 12 observation stations were all situated near the inner shore of the atoll, and the value of the mean gradient was about 60×10^{-9} c.g.s. The values of the differences of curvature multiplied by the gravitational acceleration varied from 60×10^{-9} to 280×19^{-9} c.g.s. These observed values have been compared with those calculated for each station under several assumptions as to the formation of the atoll. The effective depth of the coral reef is found to vary from 243 to 1000 metres, according to the assumptions of the density of the foundation. The estimation of depth may be subject to several criticisms. The author has taken 1·69 as the mean density of the coral reef, although one boring suggested compression, with greater density at the lower part, which would make the depth obtainable above too small. H. H. Ho.

918. *Lunar and Solar Diurnal Variations of Water-level in a Well at Kew Observatory.* **E. G. Bilham.** (Roy. Soc., Proc. 94. pp. 476–478, July 1, 1918.)—It has been shown that the experimental well at Kew Observatory responds to the lunar fortnightly oscillation of mean level in the Thames. The sensitiveness of the water-level to barometric pressure has also been investigated [Abs. 235 (1918)]. The present paper deals with the effects of the short-period tides in the solar and lunar series, S_1, S_2, S_3, S_4, and M_1, M_2, M_3, M_4. Well-marked solar and lunar diurnal variations were found in each month of the period Aug. 1914 to Aug. 1916, and these take the form of double oscillations with two maxima and two minima during the 24 hours. The range of movement was in each case found to be closely associated with the mean height of the water in the well, the correlation coefficients being 0·89 (lunar) and 0·90 (solar). A similar relation had previously been found to exist in the case of the barometric pressure. The amplitudes of the solar semi-diurnal oscillation are of the expected order of magnitude and the ratio of S_2 to M_2 for high level (0·27) is in good agreement with the result from the Thames. Combining the lunar and solar semi-diurnal tidal oscillations, it is computed that "spring tides" occur in the well 3·3 days after they occur in the river, so that this represents the actual time taken by solar and lunar semi-diurnal waves to travel through the subsoil from the river to the well, a distance of about 300 yards. The corresponding time in the case of the lunar fortnightly tide is 5·1 days. A. W.

919. *Astronomical Consequences of the Electrical Theory of Matter.* **G. W. Walker.** (Phil. Mag. 35. pp. 327–338, April, and p. 508, June, 1918.)—In reference to Lodge's and Eddington's recent papers [Abs. 470 (1918)] the author claims that there is a "parting of the ways between the logical development of electrodynamics and the doctrine of relativity," and that the main issue may be summarised in his statement that the relativist assumes that "the kinetic energy of a moving electrical system is a function of the speed only, and is independent of the direction of motion," and "that this assumption is not consistent with the fundamental electromagnetic equations for the ether supposed immobile, and that the energy, or preferably the modified Lagrangian function, depends on the acceleration as well as on the speed of the system, and involves also the relative direction of these. The statement here attributed to relativists is shown to be inconsistent with the fundamental equations. Further, the author questions the applicability of the Fitzgerald-Lorentz contraction, proved for uniform motion only, to the Michelson-Morley experiment; discusses the bearing of the Kaufmann experiment on the question; suggests the possibility of constructing, on Lodge's lines, a satisfactory theory of the anomaly in the motion of Mercury's perihelion, by introducing the more general type of Lagrangian function, and claims that Einstein's solution of this problem implicitly involves the assumption of the comparatively large dependence of the attraction on the relative velocity expressed by the formula $\mu = \mu_0(1 + 5/2 \,.\, v^2/c^2)$. He shows that one effect of the difference between longitudinal and transverse electromagnetic masses will be a change in the plane of a planet's orbit. [The second paper consists of numerical corrections of calculations in the first.] **A. S. Eddington.** (*Ibid.* 35. pp. 481–487, June, 1918.)—The author points out that Walker's thesis—that the Lagrangian function depends on the acceleration as well as on the velocity—cannot be a point-of-cleavage between relativity and non-relativity dynamics. The contention is that the separation of the Lagrangian function into two parts, the kinetic energy, a function of velocity only, and the force-function, a function only of position in the field of

force, as assumed in Newtonian dynamics of a particle, and in the quasi-stationary treatment of the problems under consideration, is inadmissible, and that there is a cross-term involving both the velocity and the force (or acceleration). Walker's treatment associates this cross-term with the kinetic energy, while Lodge and the author group it with the force-function in the suggestion that the force-of-gravitation involves a term depending on the velocity. The distinction appears to be purely verbal. Moreover, it is essential to an out-and-out relativity theory that this cross-term should exist, and it is surprising to find relativists represented by Walker as opposed to it. The author argued that the hypothesis $m = m_0(1 - v^2/c^2)^{-1/2}$, as applied to the astronomical problem, was irreconcilable with observation. Walker rejects it more summarily. The author suggests that E. Cunningham's proof [Principle of Relativity, p. 206], based on statistical mechanics, of the applicability of the Fitzgerald-Lorentz contraction to the Michelson-Morley experiment, appears to be sound; but the proof holds only for uniform motion, and according to Einstein's latest theory, the relation does not hold for non-uniform translations. The author formulates the relativity theory of Kaufmann's experiment thus :—Consider an electron momentarily at rest, but continuously accelerated, in an electric field E and in a magnetic field H; this acceleration is determined by $Ee = ma$, where e/m is a universal constant for the magnetic electron. This equation may be taken as the definition of E. Now choose new coordinates with respect to which the electron has an instantaneous velocity v, E and H assuming known values E′ and H′, then a' will be obtained from Lorentz's space-time transformation. Recent repetitions of Kaufmann's experiment then confirm with considerable accuracy the predicted relation between a' and v when E′ and H′ remain constant. And this confirms the relativity theory where most in doubt, as it makes the Lorentz transformation hold good for the boundary conditions, whatever they may be, at the surface of an electron; and it is generally admitted to hold good for the field equations. Respecting Walker's suggestion that a solution of the astronomical problem might possibly be obtained if the more general type of Lagrangian function were introduced, the author points out that he already has three constants at his disposal, and that the components of the unknown solar motion would provide three more, and with six constants at disposal he could scarcely fail to secure a forced agreement of the perihelia and eccentricities of the four inner planets, and it would be difficult to find any observational test for such a theory. With respect to Walker's claim, that Einstein's theory involves the relation $\mu = \mu_0(1 + 5/2 . v^2/c^2)$, the author is unable to see how any possible interpretation of his theory can reduce to this, and points out that in any case a theory which deduces the exact motion of Mercury from a general principle stands on a different footing from theories which merely use the motion of Mercury to obtain an empirical determination of their arbitrary constants. Referring to the recent comment of Jeffreys [Abs. 686 (1918)] on the scant attention given to the discordance of the node of Venus, the author shows in detail why it has been considered too small to be of importance. **A. D. Fokker.** (*Ibid.* pp. 205–206, Aug., 1918.)

G. W. DE T.

LIGHT.

920. *Photometer for Measuring Photographic Densities.* **D. E. Benson, W. B. Ferguson** and **F. F. Renwick.** (Phot. J. 58. pp. 155–164; Disc., 164–166, April, 1918.)—The photometer described utilises a Lummer-Brodhun cube, the source being a small glow-lamp run from a 6-volt battery, and giving 15 c.p. In these circumstances it is possible to measure not only the density of ordinary photographic negatives, but also the higher densities used in X-ray work.

The principle of the instrument consists in the comparison of the brightness of an opal plate covered by the medium to be tested, with that of a similar plate illuminated by the same source, but at a much greater adjustable distance. This distance is varied by altering the position of a double mirror by which the light is received and then returned on its original path (thus traversing twice the distance to the mirror). The work demands a concentrated powerful light and it is suggested that the "pointolite" lamp would best answer the purpose. The accuracy was estimated at about 0·4 %.

J. S. D.

921. *Ultra-violet Transmission of Clear and Cobalt-Blue Glasses.* **M. Luckiesh.** (Frank. Inst., J. 186. pp. 111–113, July, 1918.)—The author some years ago found that cobalt glass appeared to be more transparent than clear glass to ultra-violet rays in the neighbourhood of 300 μμ. Recently he has obtained conclusive evidence that such is the case. Clear and blue glasses (soda-lead) were used (1) of equal thickness, and (2) of the same content except that the blue glass contained in addition a very small percentage of cobalt. Clear and blue specimens of the same thicknesses were compared in pairs by photographing the spectra of (i) the quartz mercury arc, (ii) sunlight, and (iii) the bare iron arc through each. Various thicknesses were studied, but for each comparison pair the thickness of the two glasses was the same, and the photographic exposures were identical. The experiments established the fact that the glass containing the slight amount of cobalt was more transparent to the lines near 300 μμ. Hence the addition of a slight amount of cobalt may be of practical advantage in certain cases. A. W.

922. *Measurement of Transmission Factors.* **M. Luckiesh** and **L. L. Mellor.** (Frank. Inst., J. 185. pp. 551–552, April, 1918.)—The author has previously advocated that measurements of the reflection-factor of surfaces not completely diffusing should be made by highly diffused light. The present investigation relates to partially diffusing glasses of the sand-blasted, etched, ribbed, or pebbled type. By an integrating sphere the transmission factor was determined (1) for a narrow pencil of light striking the specimen of glass vertically, (2) for hemispherical illumination by highly diffused light. In general the transmission factor is smaller for diffuse illumination; with the narrow pencil of light it is less when the smooth side of the glass faces the light than when the rough side is presented, the difference being 5 % for sand-blasted or etched glasses but as much as 50 % for certain ribbed glasses. In most cases the transmission factors varied between 0·70 and 0·85.

J. S. D.

923. *Theory of the Polarisation Prism.* **H. Schulz.** (Zeits. Instrumentenk. 38. pp. 69–75, May, 1918.)—In a previous paper (*Ibid.* 36. pp. 247–251, 1916) the author gave formulæ for use with polarisation prisms in which the crystal axis is parallel to the refracting edge, and by consideration of the properties of rays lying outside the principal section found the limiting values for a symmetrical field of view to be smaller than they were previously thought to be. The present paper deals in a similar manner with prisms in which the crystal axis lies in the principal section. In this case the position of the axis is a factor which has to be taken into account as well as the refractive index of the material. Several interesting diagrams are given. A. W.

924. *Investigations of Anisotropic Liquids.* **Y. Björnståhl.** (Ann. d. Physik, 56. 3. pp. 161–207, July 23, 1918.)—The author describes at length the experimental arrangements employed in his investigation, which was made with a König-Martens spectrophotometer, and then gives the results in the form of tables and curves for the liquid sazoxyphenetol, azoxyanisol, and anisaldazine. For details the original must be referred to. The main points dealt with are given in the author's summary which is here reproduced.

(1) The light extinction varies with the time ; (2) it increases with rise of temperature and (3) decreases with increase of wave-length. (4) Conclusions are drawn from this behaviour as to the nature of the extinction and the size of swarm.

When subjected to an electric field the following effects were found : (I) A sort of kataphoresis is observed. (II) A momentary streaming takes place when the field is put on. (III) The extinction increases suddenly at about 100 volts/cm. to a value which then remains nearly constant. This latter effect increases with rise of temperature and with increase of wave-length. (IV) Certain anisotropic liquids become doubly refracting in an electric field, such double refraction reaching a state of saturation. L. H. W.

925. *Diffraction of Light by a Perfectly Reflecting Cylinder.* **T. K. Chinmayanandam.** (Indian Assoc. for Cultivation of Science, Proc. 3. Pt. 5. pp. 96–123, 1917.)—This paper is devoted to the further development of N. Basu's investigations [Abs. 363 (1918)]. Formulæ have been obtained for the distribution of light intensity in the various parts of the field, and verified by two independent experimental methods—photometric comparison of the maxima and minima of illumination, and the determination of their relative positions, in the case of a small polished glass cylinder of about 1·5 cm. radius. The experimental methods are described in detail and the theoretical and experimental results tabulated for comparison. The lines of flow of energy throughout the field are discussed mathematically and the results illustrated graphically. Interesting photographs of the interference fringes surrounding the cylinder are reproduced. G. W. DE T.

926. *Tracing Rays through an Optical System.* **T. Smith.** (Phys. Soc., Proc. 30. pp. 221–233, June, 1918.)—In an earlier paper on this subject [Abs. 1399 (1915)] the author gave formulæ by means of which a ray in three dimensions could be traced through a system of coaxial spherical refracting surfaces. These formulæ are algebraic and do not require the use of any tables, being intended for use in conjunction with a calculating machine. The present paper contains the modification of these formulæ generally used for rays in an axial plane, and, for both two- and three-dimensional cases new formulæ which are universally applicable, so that the calculations can, if

required, be carried out entirely by mechanical means. The present paper also includes the method followed in calculations relating to transverse focal lines. The paper is mainly mathematical and cannot be usefully abstracted.

J. W. T. W.

927. *Experimental Demonstration of Constant Speed of Light from Moving Mirror.* **Q. Majorana.** (Phys. Rev. 11. pp. 411–420, May, 1918. From the French.)—A translation of the work dealt with in Abs. 50 (1918).

928. *Persistence of Luminous Impressions on the Retina.* **L. Lumière.** (Comptes Rendus, 166. pp. 654–656, April 22, 1918.)—If, in a photographic dark-room illuminated by red light, the face of a watch with a so-called "luminous" dial be observed, a curious effect is noticed. When the watch is moved to and fro, in the plane of the dial, the green luminous figures appear dissociated from the red-illuminated dial and apparently are displaced and lag behind its movement. The illumination by the red light requires adjustment so as to be suitably related to the brightness of the luminous figures and the eye should remain in darkness for 15–20 minutes in order to get the best effect. The author describes a device, using pure red and green light, for exhibiting more clearly the effect, which he ascribes to a difference in the persistence on the retina of the luminous impressions created by the respective colours.

J. S. D.

929. *Visibility of Radiation.* **E. P. Hyde, W. E. Forsythe,** and **F. E. Cady.** (Frank. Inst., J. 185. pp. 829–831, June, 1918.)—Previous data on the visibility of radiation throughout the spectrum have been obtained almost exclusively with the flicker photometer. The authors present some figures obtained from 29 observers using an ordinary Lummer-Brodhun spectrophotometer; data obtained by other observers are correlated. The max. relative visibility is located near 0·55 μ and values from 0·40 μ to 0·76 μ, the entire visible spectrum, are determined.

J. S. D.

930. *Rockets and Illuminating Shells as used in the Present War.* **A. Bergman.** (Am. Illum. Eng. Soc., Trans. 13. pp. 219–231, June, 1918.)—Rockets used in the present war are of two types: the one bursting in a brilliant flash of short duration; the other, provided with a parachute to which a star is attached, burning for a comparatively long period, viz. 30–35 secs. Illuminating shells are fired from a gun or dropped from aircraft, but otherwise resemble illuminating rockets. The chief parts of such shells are briefly described and a short account is given of shells fired from rifles and trench mortars. With the later type a range up to one mile can be attained. Some data on the candle-power and time of burning of typical illuminating shells are presented. The average c.p. of samples 1·94 in. diam. varies from 79,800 to 269,000 according to the time of burning, but the "c.p.-seconds per cubic inch" of composition remain nearly constant at about 480,000 for a wide range in speed, provided the same composition be used. This is illustrated by a diagram: data are also presented showing the nature of the fluctuation in light that occurs while the shell is burning. In the *discussion,* it was mentioned that the light comes from a flame rather than a crater, and, except for the shadow cast by the base of the flare, is nearly constant in all directions.

J. S. D.

931. *Artificial Light in Photography.* **H. Lux.** (Elekt. Zeits. 38. pp. 506–08, Oct. 18, 1917. Paper read before the Deut. Beleuchtungstechn. Gesell.,

May, 1917.)—The Perutz silver-eosin plate is found to have a sensitivity curve built of two elementary curves, the sensitivity maximum of one of which is at 464 $\mu\mu$, of the other at 555 $\mu\mu$. The latter curve in the whole of its course shows a close approximation to the sensitivity curve for the eye. By the use of suitable filter solutions it is endeavoured to isolate this curve and to bring it into more complete accord with that of the eye. A diagram is given comparing the sensitivity curves, as depending upon wave-length, for the silver-eosin plate with 5 and 10 secs. exposure; for the influence of potassium dichromate filters of strengths 1 : 50, 1 : 100, 1 : 200, 1 : 400, 1 : 800; with the sensibility curve for the eye. There is also a table giving the actinic value for different sources of light in respect to a chloro-brom-silver plate and the colour sensitised Perutz silver-eosin plate. The sources considered include the Hefner lamp, tungsten lamps, various kinds of arc lights, and the quartz mercury-vapour lamp. There appears to be a direct analogy between the results obtained and the phenomena of sight, but, in order to establish this, more experimental work is necessary. A. E. G.

932. *Covering Power of Pigments in Photographic Prints.* **F. F. Renwick.** (Phot. J. 58. pp. 140–152; Disc., 153–155, April, 1918.)—The *discussion* deals with the covering power of pigments, *i.e.* the capacity of solid particles suspended in a medium (such as dried oil, gum, casein, etc.) to obscure the surfaces on which they are laid. The paper has special reference to photographic prints, but the principles apply generally to pigments of the above type. The starting-point in the investigation, which is largely mathematical, is the formula, $D_r = \log 1/[(1 - C)\tau^2 R_\rho + C]$, where D_r is the reflection density, C the surface reflection, T the transmission of the deposit, and R_ρ the reflecting power of paper. In connection with this formula it has been stated that the density of a print depends on the surface reflection, the reflecting power of paper stock and the mass of silver. Density was regarded as essentially a function of the latter quantity. Several objections to this statement are raised. While density is generally proportional to the mass of silver, this cannot be true when a white diffusing medium, such as opal or white paper, is used to diffuse the light; it is also assumed that the silver pigment grains in a print do not reflect light. The author then offers a mathematical treatment intended to remove these objections, which is broadly checked by experimental data. J. S. D.

933. *Methyl-violet as a Red-sensitiser of the Photographic Plate.* **U. Yoshida.** (Kyōtō, Coll. Sci., Mem. 3. pp. 69–71, April, 1918.)—50 cm.^{3} of ethyl alcohol are mixed with the same volume of water, and 5 cm.^{3} of ammonia added. This solution is cooled by melting ice. Next 1 gm. of methyl-violet is dissolved in 1000 cm.^{3} of cold absolute alcohol, and 5 cm.^{3} of this is added to the former. The solution thus prepared is well stirred, and cooled by melting ice. The photographic plate to be sensitised is soaked in this solution for 5 mins. or more, and then rinsed in alcohol and dried. Diagrams are given showing the comparative results obtained with plates so sensitised and in their ordinary state. It is clearly seen from these curves that the portion of the spectrum to which the plate is most strongly sensitised is in the neighbourhood of 640 $\mu\mu$. Thus the photographic plate is rendered sensitive to light of the shorter wave-lengths in the red. With regard to the sensitiveness to red light, both in the intensity and the limit of the wave-length, the plate thus sensitised is never superior to the panchromatic plate of Wratten and Wainwright; it is, however, ascertained

that the plate thus sensitised is more sensitive to the light of shorter wave-lengths than the latter.

When an orthochrome plate is sensitised by methyl violet a new maximum of sensitiveness at 640 $\mu\mu$ is found in addition to the original maximum at 560–570 $\mu\mu$; and the spectrum region to which the plate is made sensitive extends to about 650 $\mu\mu$. Though the sensitiveness of the plate thus sensitised to the red is a little reduced at the green and yellow region, it could be used as a rapid plate sensitive to nearly all wave-lengths except those of extreme red. A. E. G.

934. *The Electronic Theory of the Natural Optical Activity of Isotropic and Anisotropic Liquids.* **M. Born.** (Ann. d. Physik, 55. 3. pp. 177–240, May 17, 1918.)—All theories which deal with the optical properties of matter agree in the assumption of orientated particles within the substance which are caused to oscillate by the light waves. This mode of representation has led to a unique picture of the mechanism for the explanation of dispersion and absorption of magnetic and electro-optical phenomena. An important class of optical properties has up till quite recently only been barely included within this theory, viz., the ability of certain substances to rotate the plane of polarisation, together with certain allied qualities which are termed "natural optical activity." The nature of these phenomena led to the assumption of a screw-like structure for the molecule; such a statement on the build of the whole molecule has, however, no place in the usual dispersion theory, which only deals with single, quasi-elastic, united electrons or ions. In consequence optical activity was only formally attached to the electromagnetic theory of light, the fundamental equations of the dispersion theory being enlarged by terms to express the screw-like asymmetry, which, however, could not be ascribed to any known force effect. In spite of this want of a comprehensive molecular theory, the rotation of the plane of polarisation has been an important aid to the crystallographer and chemist in the investigation of structural relationships, *e.g.* the stereochemical idea of asymmetrical molecules. The author has previously made proposals whereby a formula system might be evolved to explain optical activity in the case of crystals, namely, from the view-point of the coupling of the oscillating particles, and the finite character of the ratio between the particle distance and the wave-length. In the crystal lattice these conditions must obtain. In the theory of the specific heat of solid bodies the necessity has arisen of considering the alteration in activity of the oscillating particles. The solution of the oscillation equation of the crystal lattice thus becomes an approximation process. For oscillations having the frequency of light the known laws for inactive crystals follow as a first approximation; supplementary terms introduced as a second approximation apply to active asymmetric crystals. The author has similarly sought to explain rotative ability for liquids and gases. Here molecular rearrangement has to be considered. During the same period C. W. Oseen has investigated the problem on the assumption that the coupling is an electromagnetic effect according to the known dipole formula of H. Hertz. The new method has now been applied to liquid crystals, many of which exhibit extremely high rotative capacity.

The present paper includes a revised statement of the author's previous work. The latter contained many blanks and defects, which are now shown to have a common origin, since the author had not then succeeded in solving the generalised dispersion formula by which the oscillation equations of a coupled mechanical system could be so presented, as to give the characteristic properties of the molecule whereby rotation ability could be expressed by formulæ. All the defects have now been shown to depend on the degree of accuracy of the approximate solution and disappear by correctly performing the calculations as demonstrated in the paper. A new series of data have now been obtained, which, in their totality, explain a large number of the experimentally known facts of optical activity.

The molecule is regarded as a system of numerous positively and negatively charged particles which are coupled mechanically and brought into oscillation by the action of a light wave. The magnitude of the effect is calculated for a given orientated molecule from the oscillation equations which are generalised in two directions as opposed to the corresponding equations of the dispersion theory, viz., (1) the particles are coupled; (2) the phase of the disturbance is not regarded as the same for every particle of a molecule. Respecting the latter, the calculation is not performed for any given ratio of molecular diameter to wave-length, since terms are neglected for second and higher degrees. The electric moment is found from the displacement of the particle, which takes up a given position towards the wave normal. To obtain the electric moment of the volume unit, an average of all possible positions of the molecule is requisite, whereby, in the case of anisotropy, a given distribution law is accepted. The electric moment of the volume unit as a function of the electric field strength of the incident wave is, however, the only vector in the Maxwell equations which depends on the substance. If this be known, then the problem of light propagation is solved.

The general optical formulæ are next exhaustively discussed, especially with respect to the nature of molecular forces and symmetry relationships. Application is made to three cases: (I) isotropic liquids with natural optical activity; (II) liquids rendered active by electric fields (the Kerr effect); (III) natural anisotropic liquids (liquid crystals). A large number of known qualitative laws are established, *e.g.* the molecular explanation of the spiral structure. By treatment of the Kerr phenomenon the known theory of Langevin is partly generalised by consideration of the natural moments of the molecule. The optical phenomena for liquid crystals are explained for the most part on molecular grounds. A relation between the refractive indices which deals with the consideration of molecular equality of isotropic and anisotropic phases is quantitatively proved and confirmed for many cases. Under the assumption that the electric moment of the molecule is the chief cause of anisotropy, the size of the molecule has been calculated, with a very plausible result. Section 1 of the paper considers the structure of the molecule and the distribution law. Section 2 investigates the molecular vibrations caused by a light wave. In Section 3 the average electric moment of the volume unit is evaluated. Section 4 discusses the connection of the parameter of the activity with the union and coupling of the particles, 14 relationships being developed. In Section 5 the laws of light propagation are established. In Section 6 isotropic substances are discussed. Section 7 deals with double refraction in the electric field (the Kerr-effect). Section 8 investigates liquid crystals. These are liquids which become spontaneously anisotropic below a certain transformation temperature. In order to state the distribution law of the molecular axes, an exact knowledge of the thermodynamic molecular state is requisite. This knowledge has still to be obtained. In any case it must be known whether the molecule remains unaltered after the transformation, or whether it suffers a change of form, *e.g.* disintegrates or associates to greater complexity. This subject is considered at great length, the following substances having been investigated: Ethoxybenzalamino-α-methyl cinnamic acid ethyl ester, *p*-cyanbenzalamino-cinnamic acid —active amyl ester, cholesteryl phenyl carbonate, cholesteryl nitrobenzoic acid.

Numerous tables of results accompany the paper. H. H. Ho.

935. *On the Rotation Spectrum of a Gas: Hydrogen.* **G. Hettner.** (Ann. d. Physik, 55. 7. pp. 545–560, June 21, 1918. Theoretical Part of Dissertation, Berlin.)—The long-wave ultra-red absorption bands of hydrogen, as well as the complex structure of the short-wave bands, have been explained on Bjerrum's theory by the rotations of the molecules in conjunction with the quanta theory. [See Abs. 1954 (1918) and 493 (1917).] The Bjerrum theory has also been found applicable to other gases. The present paper is concerned with further extensions of this theory. Bjerrum uses that conception of the quanta theory by which the static orbits are the only ones possible, and he assumes that to the static orbits of molecules there are simple corresponding frequencies which are absorbed. Whether the latter assumption is correct cannot be decided, since this conception of the quanta theory is not compatible with the absorption law derived from electrodynamics, and in consequence renders fresh hypotheses necessary. These are forthcoming in the present paper. Only the rotations of molecules about their principal axes will be taken into account. With rectilinear, *i.e.* diatomic, molecules in which a principal moment of inertia vanishes, or with molecules having three equal moments of inertia, these motions are the only ones possible, but in all other cases, *e.g.* the H_2O molecule, other movements occur which probably account for the absence of absorption bands. Since, however, the theory must now be supplemented, Planck's view has been utilised according to which absorption follows the electrodynamic laws, and therefore all compatible motions are in accord with classical mechanics. Planck has treated the theory of the rotation spectrum from this standpoint, and his results refer to the case where a principal moment of inertia disappears, with equality of the remaining two. A series of absorption lines were obtained with frequencies w, $2w$, $3w$..., which presume an energy distribution between the molecules in agreement with that derived from the quanta hypothesis. This calculation cannot, however, be directly applied to hydrogen, whose rotation spectrum is best known, and, in the case of the water molecule, no principal moment of inertia disappears. It is difficult, consequently, to treat these cases analogously to Planck's method. In the paper, however, it is shown how the entrance of series of absorption lines can be indicated, and how, in particular, the two series of hydrogen lines can be explained. The following assumptions have been made:—(1) The molecules are regarded as rigid and possessing a constant electric moment. (2) In the case of any principal moment of inertia the density distribution is constant within the element region of probability, and possesses singularities at the boundaries.

H. H. Ho.

936. *Water-vapour Band λ3064 and Solar Spectrum.* **A. Fowler.** (Roy. Soc., Proc. 94. pp. 472–475. July 1, 1918.)—Taking the wave-length measurements of the chief water-vapour band λ3064 made by Meyerheim and by Grebe and Holtz, which have been found sufficiently accurate for effective comparison with the solar tables of Rowland, it is found that the result of the

comparison is to prove that the band is quite strongly represented in the solar spectrum, and accounts for a large number of lines which were previously unidentified. Of 50 lines included in the comparison table given, it is seen that, while 12 are obscured in the sun by closely adjacent metallic lines, the remaining lines show a very close agreement in wave-length with solar lines, and a sufficiently consistent correspondence of intensities. Further comparison shows that at least 150 of the solar lines in the region of the λ3064 band may be confidently assigned exclusively to water-vapour, and it is probable that many additional solar lines will be traced to water-vapour when sufficiently accurate measurements of the other bands become available for comparison. Besides accounting for a large number of previously unidentified lines, the identification of the water-vapour band in the solar spectrum is of interest as furnishing further evidence of the existence of oxygen in the sun.

A. W.

937. *Ultra-violet Band of Ammonia and its Occurrence in the Solar Spectrum.* **A. Fowler** and **C. C. L. Gregory.** (Roy. Soc., Proc. 94. pp. 470–471, July 1, 1918.)—The investigation here described was undertaken primarily in order to determine whether group P in the ultra-violet region of the solar spectrum might not be mainly due to the presence of ammonia in the absorbing atmosphere of the sun. Ammonia was already known to give a remarkable band in this region, having its greatest intensity near λ3360, but existing records of the component lines were inadequate for comparison with the solar tables. Photographs were accordingly taken with instruments of various dispersions, ranging up to the third order of a 10-ft. concave grating, a copper arc in an atmosphere of ammonia being employed as the source in the latter case. In view of the unusual appearance of the band, an attempt was made to elucidate the chief features of its structure. The chief ammonia band consists of a bright central maximum about λ3360, a secondary maximum about λ3371, and a number of lines, which are arranged in groups of three, extending to a considerable distance in both directions. The lines composing the two maxima are very closely crowded together, and have been found to be arranged in series of ordinary type. The components of the groups of three are widely separated near the central maxima, but the intervals rapidly diminish, and there is final coalescence at λ3450 towards the red, and at λ3287 towards the violet, where the lines fade out. The groups of three, however, are not symmetrical with respect to the central maxima, and they show marked peculiarities, so that they are very imperfectly represented by the formulæ usually employed for band spectra. The comparison with the solar spectrum is considerably complicated by the presence of lines of metallic origin, but there is abundant evidence that many of the fainter solar lines are due to ammonia. The most convincing proof is afforded by the strongest parts of the central maximum, for which there is a complete correspondence of the solar and laboratory spectra, except that the line λ3360·44 in the sun may be slightly reinforced by a line which Rowland attributes to nickel, though it is not given as such by Exner and Haschek. The agreement is emphasised by the occurrence of patches of continuous background (dark in the sun) which are identical in the two spectra. There is also a sufficiently consistent representation of the groups of three, and of the lines composing the secondary maximum of the ammonia band. Of the 260 band lines of ammonia in the region λ3450 to λ3286, there are 140 which correspond with previously unidentified faint lines of the solar spectrum. About 100 of the

remaining lines are obscured by lines for which metallic origins have been found, or fall upon lines which are too strong in the sun to be assigned solely to ammonia, and the few which fail to appear in the sun are all of low intensity. A. W.

938. *Reversal of Spectrum Lines produced by a Spark under Water.* **T. Mashimo.** (Kyōtō Coll. Sci. Mem., 3. pp. 73–79, April, 1918.)—Using the method described by Henri [Abs. 1818 (1913)], and employing several different metals as electrodes, the author found that the metallic lines due to the electrode appeared mingled with the continuous spectrum; and further, that some of these lines were always reversed while others remained unreversed, so that Henri's method affords a convenient means for studying the behaviour of different lines in the spectrum of a spark under water. The phenomenon is not by any means a simple one, and depends greatly on the mode of excitation of the spark. The metals employed as electrodes were Al, Zn, Cd, and zinc amalgam, which yielded mercury lines. A detailed description is given of the results obtained in each case. With Al it was found that the lines of the first subordinate series were more easily reversed than those belonging to the second subordinate series. A. W.

939. *Infra-red Absorption Spectrum of Water-vapour.* **G. Hettner.** (Ann. d. Physik, 55. 6. pp. 476–495, June 14, 1918. Extract from Dissertation, Berlin.)—Describes an elaborate investigation of the absorption spectrum of water-vapour in the region from $0{\cdot}8\,\mu$ to $34\,\mu$. A detailed account is given of the absorption chambers, of which two were employed, and also of the spectrometer arrangements. The source of light was a Nernst lamp. A table is given of the wave-lengths of all the maxima observed, together with a graphical representation of their character. Altogether 78 maxima were detected, 20 of which had been previously observed by other experimenters. [See Abs. 1954 (1913).] A. W.

940. *Natural Frequencies of Nitrates in the Infra-red.* **C. Schaefer** and **[Miss] M. Schubert.** (Ann. d. Physik, 55. 8. pp. 577–588, June 28, 1918.)—The authors have previously investigated the selective reflection of numerous carbonates and sulphates in the spectral region 1–20 μ, using ordinary and also polarised light [Abs. 1241 (1916)]. Pfund has dealt with a few nitrates, and found with each a maximum at about $7{\cdot}45\,\mu$ [Abs. 1562 (1906)]. The present investigation deals with the nitrates of Na, K, Rb, Pb, Sr, Ba, and Hg. In each case, using ordinary light, three maxima were observed, whose wave-lengths were approximately $7{\cdot}3\,\mu$, $13{\cdot}74\,\mu$ and $15{\cdot}58\,\mu$. The maximum at $7{\cdot}3\,\mu$ was found to be much more pronounced than the other two. With $HgNO_3 + H_2O$ a fourth maximum was observed at $10{\cdot}08\,\mu$, the three others being at $8{\cdot}06\,\mu$, $12{\cdot}50\,\mu$ and $15{\cdot}92\,\mu$. Investigation with polarised light led to the conclusion that with nitrates giving uniaxal crystals the three maxima are all double, the components corresponding to the ordinary and extraordinary ray. With nitrates giving biaxal crystals, the three maxima have each three components, which correspond to the oscillations parallel to the axes of the greatest, mean and least index of refraction. The results point to the conclusion that the NO_3 group, in whatever combination it occurs, has proper frequencies of its own, and is thus similar in behaviour to the sulphate and carbonate groups. A. W.

941. *Resonance and Ionisation Potentials for Electrons in Cadmium Vapour.* **J. T. Tate** and **P. D. Foote.** (Bureau of Standards, Bull. 14. pp. 479–486, [Sci. Papers, No. 317], 1918.)—The general method employed in the work here described was the same as that used by Tate in the case of mercury vapour. The experimental procedure consisted in applying a constant retarding potential of about 2 volts between the net and the outside cylinder and measuring both the total current from the hot wire and that portion of it which reached the outside cylinder against the retarding field, as functions of a varying accelerating potential applied between the hot wire and the net. The results are exhibited graphically.

The two types of electronic impact previously found in mercury vapour are also found in cadmium vapour. The sudden decrease in current through the retarding field at an effective potential of 3·88 volts indicates a loss in energy of electrons having this critical velocity on impact with a cadmium atom. The fact that there is no corresponding increase in the total current at 3·88 volts shows there is no appreciable ionisation at this potential. When the velocity of the electrons corresponds to 8·92 volts, the collisions again become inelastic, and the sudden increase in the total current indicates that the loss in energy of the colliding electrons has gone over into separating from the nucleus one or more of the electrons bound in the atom. Under conditions such that only the first type of collision could take place McLennan and Henderson have shown that light of the single wave-length λ3260·17 is emitted. That the entire spectrum of cadmium is probably radiated at potentials above 8·92 volts is indicated by the appearance of a visible glow around the hot wire at 9·2 volts. McLennan and Henderson were able to get the complete spectrum at about 15 volts. Substituting the frequency corresponding to λ3260·17 in the relation $h\nu = e\mathrm{V}$, and taking $h = 6{\cdot}56 \times 10^{-27}$ erg sec., the theoretical value of the resonance potential is found to be 3·79 volts, as compared with the observed value 3·88 volts. If the ionising potential is calculated on the basis of Bohr's theory, using the frequency $\nu = (1{\cdot}5, \mathrm{S})$ of the cadmium spectrum ($\lambda = 1378{\cdot}69$) in the above relation, the theoretical value 8·97 volts is obtained, as compared with the observed value 8·92 volts. The agreement is within the probable error of the experiment. The results obtained for the resonance and ionisation potentials for electrons in Hg and Cd vapours must be regarded as another example of the fundamental accuracy of conclusions based upon Bohr's theory of atomic structure. Especially is this true of the results for Hg vapour, since for a long time the view that ionisation took place at 4·9 volts, together with the fact that the radiation emitted at that potential was monochromatic, formed a serious obstacle to the complete acceptance of the theory. [See Abs. 1278 (1917).] A. W.

942. *Stark-effect for Helium Lines.* **T. Takamine** and **N. Kokubu.** (Kyōtō, Coll. Sci., Mem. 3. pp. 81–92, April, 1918.)—A continuation of previous work [Abs. 955 (1917) and 840 (1918)]. The present paper describes the results obtained by further investigations relating mainly to the more refrangible helium lines. Lo Surdo's method was again used. Nine lines were dealt with in the earlier work and results are now given for the eleven lines λλ4169, 4144, 4026, 4009, 3965, 3868, 3830, 3820, 3614, 3448, and 2945. The results are compared with those of Stark, Brunetti, and Koch. It has been found that there are three different ways in which helium lines are affected by an electric field, namely: (i) symmetrical decomposition (λ4686 line); (ii) non-symmetrical decomposition (diffuse series lines of helium and parhelium); (iii) one-sided displacement (principal series lines and sharp series lines of helium and parhelium). Of (iii), only the lines

belonging to the principal series of parhelium are displaced toward the violet side, while the other three series lines are all displaced toward the red side. Diffuse series lines are usually accompanied by an isolated component on the violet side, whose starting-point approaches nearer and nearer to the initial line as the term number increases. The line λ3830, whose position was calculated by Koch, but not observed by him, appeared in some of the photographs taken in the present experiments. Beside the helium lines mentioned above, two lines at λ2804 and λ2482, probably due to mercury, were found to be displaced toward the red in the electric field. Numerous diagrams and photographs are given. A. W.

943. *Asymmetrical Distribution of Corpuscular Radiation produced by X-rays.* **E. A. Owen.** (Phys. Soc., Proc. 30. pp. 133–142; Disc., 142–143, April, 1918.)—The ratio of emergent to incident corpuscular radiation in the case of the two salts, potassium bromide and silver nitrate, has been investigated when the exciting X-radiations were the characteristic radiations of copper, bromine, silver, and tin. The ratio has the same value whether the salt is in the wet or in the dry state, or whether amorphous or crystalline. The value of the ratio was found to be approximately the same for each of the two salts, and is equal to 1·17. This is approximately the same figure as that found by other observers in the case of the metals, gold and silver. These results would indicate that the asymmetry observed in the case of corpuscular radiation produced by X-rays of wave-length ranging from the characteristic radiation of copper to that of tin, is practically constant and independent of the nature of the screen which emits the corpuscles, both as regards the substance of the screen and the state of that substance.

A. B. W.

944. *The Continuous X-ray Spectrum.* **J. E. Lilienfeld.** (Phys. Zeits. 19. pp. 263–269, June 15, 1918.)—The radiation emitted from an X-ray tube can generally be distinguished under two forms—the spectrum peculiar to the atom of the anti-kathode (characteristic radiation), and the "continuous" (or non-characteristic) spectrum. After discussing the theoretical and experimental observations of such physicists as Wien, Sommerfeld, Rutherford, etc., the author proceeds to give an account of his own experiments in connection with the non-characteristic spectrum. His conclusions and results are summarised as follows :—(1) It is possible to produce "continuous radiation" of great intensity over a range of wave-lengths which are much shorter than the wave-lengths of the characteristic K-radiations of the materials of the anti-kathode. (2) The most intense part of the continuous band of radiation breaks off, towards the shorter wave-lengths, at a definite limit; whilst the less intense part of the band shows a diminution of intensity as required by the quantum theory. That part of the spectrum towards the high-frequency end needs further investigation. (3) The intensity of the total continuous-radiation (*Bremsstrahlung*) so far as the intensity distribution shows, varies little with the material of the antikathode. Hence it is improbable that the "*Abbremsung*" results from the kathode rays in the atom-field. A. B. W.

945. *Photographic Analysis of the X-ray Spectrum of Pt and Ir.* **J. E. Lilienfeld** and **H. Seemann.** (Phys. Zeits. 19. pp. 269–271, June 15, 1918.) —Seemann, in a previous paper [Abs. 960) 1917)], has obtained, by a special method, remarkably clear photographic records of the X-ray spectrum of platinum and iridium. From these photographs the values of the wave-lengths of the K-lines of these elements were tabulated. In addition to the sharp K-lines on the photographs, a continuous band was also observed. The present paper deals with a detailed analysis of this "continuous system" (*Bremsstrahlung*). The authors have made careful intensity measurements extending over the whole spectrum—including both "characteristic" and "continuous" radiations. The graph of intensity–wave-length shows a very sudden fall at the short-wave end of the continuous radiation. This occurs at wave-length $0{\cdot}073 \times 10^{-8}$ cm., shorter wave-lengths being entirely absent. It is noteworthy that this wave-length is less than that of the γ-rays from RaC, viz. $0{\cdot}1 \times 10^{-8}$ to $0{\cdot}09 \times 10^{-8}$ cm. It is consequently shorter than the shortest X- or γ-ray wave-length previously measured.

The results of the above investigation are discussed in relation to a previous paper by one of the authors [see preceding Abs.]. A. B. W.

946. *Calculation of the Secondary Radiation from a Plate.* **R. Glocker.** (Phys. Zeits. 19. pp. 249–257, June 15, 1918.)—A mathematical paper dealing with the subject in seven sections: (1) The characteristic secondary radiation emitted from the front of the plate. (2) The scattered radiation emitted from the front of the plate. (3) The characteristic secondary radiation emitted from the back of the plate. (4) The scattered radiation emitted from the back of the plate. (5) Generalisation of the formulæ for the case of oblique incidence of the primary radiation. (6) Extension of the formulæ for divergent primary beams. (7) Application of the formulæ in absorption measurements. A. B. W.

947. *Penetrating Secondary Radiation produced by Canal-rays.* **M. Wolfke.** (Phys. Zeits. 19. pp. 205–208, May 15, 1918.)—In an earlier paper the author reported a new secondary radiation from canal-rays [Abs. 68 (1918)]. Further experiments on the magnetic deflection of canal-rays have made it possible to examine this penetrating secondary radiation more completely. The author's conclusions are summarised as follows:— Using a photographic method, and deflecting the canal-rays magnetically, it has been demonstrated that the positive canal-ray particles (oxygen and nitrogen ions) on impact with Al-foil excite a penetrating radiation. The hypothesis put forward by the author, as a result of his earlier investigation, that the canal-ray particle can excite the characteristic X-radiations of the heavier elements (tin and lead), has not been verified; it appears, rather, that it behaves in this connection like a very weak radiation. A. B. W.

948. *Penetrating Secondary Radiation from Canal-rays.* **J. Wolfke.** (Archives des Sciences, 46. pp. 51–54, July, 1918. Paper read before the Soc. Suisse de Physique.)—Recently the author has published researches on a new secondary radiation produced by canal-rays [see Abs. 68 (1918)]. Still more recent work, with a different experimental arrangement, has confirmed the production of this secondary radiation by canal-rays, but at the same time the author has revised his opinions as to the character of this secondary radiation. Certain differences in the photographic effects previously observed have now been shown to be due to a "hidden parasitic phenomenon."

The question is now dealt with anew with the following result:—"The photographs show incontestably that the positive ions (canal-rays) are capable of exciting a penetrating radiation. A. B. W.

949. *Determination of the Crystal Structure of Complex Compounds.* **P. Niggli.** (Phys. Zeits. 19. pp. 225–234, June 1, 1918.)—The general geometrical properties of the regular point systems have been completely determined according to Schoenflies. Usually too little use is made of this in the exploration of crystal structure, and the author, in a book about to be published, states that much new data will be given with respect to the properties of the 230 space groups. He indicates the possibility of finding the space system of any complex crystal by means of his tables. When mass particles in general configuration (with more than two degrees of freedom) possess a diffraction power which is not vanishingly small, or is compensated in the first order, then their space system may be at once obtained by the Bragg process or by Laue photographs. If the space system and the number of molecules in the element parallelopiped be known, then the equations of the plane series can be derived, and from the intensity measurements the coordinates of the separate points can be directly determined.

Section I of the paper deals with the Bragg process. The distances corresponding to spectra of the first order may be regarded as Röntgen periods, and the determination of the space system of a crystal whose symmetry is known, is rendered possible by the fact that every space group corresponds to individual relationships of the Röntgen periods. An example is worked out in detail, potash alum being the compound selected. The working is entirely mathematical and is illustrated by 3 figures and 4 data tables.

Section II deals with the determination of crystal structure by Laue photographs. Interference photography has only received limited application for this purpose, and the author now shows how from a sufficient number of such photographs the crystal structure may be determined with the same accuracy as from spectra experiments. H. H. Ho.

950. *Foundations of the Optics of Crystals.* III. *The Crystal-optics of X-rays.* **P. P. Ewald.** (Ann. d. Physik, 54. 7. pp. 519–556, April 9, and 54. 8. pp. 557–597, April 26, 1918.)—This paper does not permit of a short abstract. The subject is dealt with under the following headings :—Introduction of some conceptions utilised in the paper ; Elementary interference field in the complete crystal ; Dynamics of the complete crystal ; Dispersion surface in the case of two rays ; Interference image of the half-crystal ; Solution of the edge problem in Laue's case ; Solution of the edge problem in Bragg's case ; The case of two rays—primary ray and one secondary ; Prospect of experimental realisation of the theory ; Summary. [See Abs. 670 (1916).] A. B. W.

RADIO-ACTIVITY.

951. *Parent of Actinium. New Radio-active Element of Long Life.* **O. Hahn** and **L. Meitner.** (Phys. Zeits. 19. pp. 208–218, May 15, 1918.)—The authors claim to have found, and prepared in a pure condition, a salt of the "hypothetical" parent of actinium. This substance, which they call prot-actinium, is a higher homologue of tantalum. It emits α-particles of 3·14 cm. range. With regard to its half-value period it is only possible at present to state that it lies between 1200 years and 180,000 years.

The growth of actinium from this substance, "prot-actinium," was observed : (1) by means of α-ray curves ; (2) by measurement of actinium emanation—daily measurements extending over a month ; (3) by the active deposit—collected in increasing quantities on a negatively charged plate.

These observations confirm Curie's value for the half-value period of actinium.

Various possible schemes are discussed for indicating the decay series of the uranium family of which prot-actinium and actinium are members.

Combining their own results with those of other observers (notably Fajans, *ibid.* 14. 951, 1918), the authors propose the following scheme of disintegration for the uranium series:—

$$\begin{tikzcd}
 & & & & \mathrm{I}_0 \arrow[r, "\alpha"] & \mathrm{Ra} \arrow[r, "\alpha"] & \mathrm{Em,\ etc.} & \\
\mathrm{Ur\ I} \arrow[r, "\alpha"] & \mathrm{Ur\ X}_1 \arrow[r, "\beta"] & \mathrm{Ur\ X}_2 \arrow[r, "\beta"] & \mathrm{Ur\ II} \arrow[ur, "\alpha"] \arrow[dr, "\alpha"] & & & & \\
 & & & & \mathrm{Y} \arrow[r, "\beta"] & \mathrm{Prot.\ Ac} \arrow[r, "\alpha"] & \mathrm{Ac} \arrow[r, "\beta"] & \mathrm{RdAc,\ etc.}
\end{tikzcd}$$

A. B. W.

952. *Life of Radiothorium, Mesothorium, and Thorium.* **L. Meitner.** (Phys. Zeits. 19. pp. 257–268, June 15, 1918.)—The results of the author's investigations are summarised thus:—

(1) The half-value period of radiothorium is found to be 1·90 years—this value being deduced from observations extending over a period of 7 years. (2) From measurements of a radium-free preparation of mesothorium (partly fresh and partly 11 years old) a half-value period of 6·7 years is now given instead of the previously accepted values of 5·5 years. For equal α-activities the γ-radiation of Ra is 1·5 times stronger than that of radiothorium and 0·9 times as strong as that of mesothorium and radiothorium in equilibrium. (3) By comparison with a radium standard solution the half-value period $2{\cdot}37 \times 10^{10}$ years has been determined for thorium.

A. B. W.

953. *Radio-activity of Thermal and Mineral Waters.* **H. Perret** and **A. Jaquerod.** (Archives des Sciences, 45. pp. 277–297, April; 336–348, May, and pp. 418–437, June, 1918.)—In these papers detailed accounts are given of a careful study of the radio-active contents of various samples of water from the Neuchatel, Jura, and neighbouring districts. In general, a single analysis has been made, but in some cases the study of the water from a certain place has extended over a period of more than two years.

The radio-activity of the waters of Neuchatel and Seeland is weak—varying from 0 to $3{\cdot}5 \times 10^{-10}$ curie per litre. The activity of all sources varies considerably with time. The emanation measured is in all cases that of radium, thorium emanation not having been detected. For different sources there appears to be no definite relation between radio-activity and temperature.

Although the reverse is usually the case, the authors find that the thermal and mineral waters examined by them show no particular radio-activity. The activity of the water increases in a very marked manner from SE. towards NW. across the chain of Jura, that is to say, from the border of Neuchatel towards the French frontier. A parallel study of two sources has shown that the maxima and minima of activity occur approximately at the same times.

A. B. W.

HEAT.

954. *A Sensitive Bath-Thermostat.* **A. N. Shaw.** (Roy. Soc. Canada, Trans. 11. pp. 129–135, 1917.)—A series of notes on a simple and sensitive form of oil bath and thermostat employed for standard cell work [see also Abs. 262 (1908)]. The containing vessel is constructed of two wash tubs, one being placed inside the other with a space of about 4 cm. between the walls. The stirrer is arranged in the centre of the bath and consists of a simple propeller which produces a downward current at the centre, spreading and rising at the sides; the heating element consisting of two bare manganin wires wound on glass tubes, each coil being of 150 ohms resistance, and connected in parallel.

The thermo-regulator is constructed from about 4½ m. of thin glass tubing approximately 1½ cm. in diam. This is bent into the form of a plane worm grid occupying a square of about 42 cm. side with spaces of about 3 cm. between bends. One end is closed while the other is bent round with an elbow below the plane of the rest of the grid and then extends out of the bath, terminating in an H-shaped portion. The object of the elbow is to prevent the toluene coming into the vertical part containing mercury. The H-shaped portion is made with three-way taps at the junctions of the horizontal arms with two verticals. One of the vertical limbs is fitted with the customary arrangement of Pt-wires for making and breaking electrical contact with the mercury. The other limb serves for adjustment of the thermostat by adding or removing mercury.

Temperature control is effected as follows:—The current through the heaters is adjusted until it suffices to maintain the bath several degrees below the temperature desired. The regulator then operates so as to switch on and off a resistance in parallel with that controlling the current through the heaters immersed in the bath. E. G.

955. *Determination of the Expansion Coefficient of Quartz Parallel to the Axis.* **S. Nakamura.** (Math. Phys. Soc., Tōkyō, Proc. 9. pp. 342–345, May, 1918.)—In Fizeau's method for the determination of the expansion coefficient of a substance, the Newtonian type of interference fringes of equal thickness is used and the displacement of the fringe measured micrometrically. Benoit and other observers used this method. In the experiment described in the paper, the author used interference fringes of equal inclination, as in Fabry and Perot's interferometer. Two half-silvered planes were kept parallel by a piece of quartz with three contact points on its two ends, and placed in a thermostat and illuminated by the green light of mercury. The number of fringes appearing or disappearing during temperature (and pressure) changes was counted, and the expansion coefficient of quartz was deduced from it. A brief theoretical note is given together with detailed descriptions of the source of light, the thermostat, the quartz examined, the silvered plates for the production of the interference fringes, and the experimental arrangement adopted. The mean expansion coefficient between 0° C. and t° C. was found to be given by the expression: $\alpha = (7{\cdot}158 + 0{\cdot}00816t) \times 10^{-6}$. The author opines that the simplicity of the present method may recommend itself for the absolute determination of α for any substance, as it requires no special care except the measurement of temperature. H. H. Ho.

956. *Ebullioscopic Determinations with a Common Thermometer.* **C. C. Kiplinger.** (Am. Chem. Soc., J. 40. pp. 1020–1023, July, 1918.)—The author describes a method whereby it is possible to read small temperature intervals on an ordinary thermometer by measurements of the parallax on an auxiliary scale. It is also possible to eliminate several troublesome errors in the boiling-point method of determining molecular weights by using but one reference point on the thermometer scale during a given determination, having established this point by the use of a known substance having a high degree of purity. By using the above method, it is possible to dispense with the costly Beckmann thermometers in carrying out molecular-weight determinations.

A. F.

957. *The Measurement of Low Temperatures.* XXVII. *Vapour Pressures of Hydrogen in the Neighbourhood of the Boiling-point and between the Boiling-point and the Critical Temperature.* **P. G. Cath** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 20. 7. pp. 991–999, and 20. 8. pp. 1155–1159, 1918. Comm. No. 152*a* from the Phys. Lab., Leiden.)—Previous determinations of the vapour pressure of hydrogen [Abs. 285 (1918)] have been extended. For the measurement of temperature an improved helium thermometer was employed. The results obtained are summarised in the following table. The temperatures have been reduced to the absolute scale, using the corrections deduced from the Leiden determinations of the compressibility of helium.

VAPOUR PRESSURE OF HYDROGEN BETWEEN ITS BOILING-POINT AND CRITICAL TEMPERATURE.

θ.	T.	p (in Cm.).	p (in Atmos.).	ΔT (Calc.—Obs.).
—248·50° K.	24·59° K.	219·92	2·8937	+ 0·05
247·48	25·61	267·99	3·5262	— 0·04
246·65	26·44	319·80	4·2080	+ 0·02
245·87	27·22	370·65	4·8770	+ 0·02
245·80	27·29	376·30	4·9524	+ 0·03
245·68	27·41	384·32	5·0566	+ 0·02
244·70	28·39	475·46	6·2561	+ 0·25
243·22	29·87	601·52	7·9148	+ 0·17
241·73	31·36	748·42	9·8476	+ 0·05
241·07	32·02	822·6	10·825	+ 0·03
240·49	32·60	893·1	11·752	+ 0·01
240·16	32·93	936·4	12·322	0·00

In the above table the pressures are given in international cm. of mercury at 0° C., and in international atmospheres respectively, the international atmosphere at Leiden being taken equal to 75·9488 cm. Hg at 0° C. The vapour pressure can be satisfactorily represented by the equation (p being expressed in international atmos.)—

$$T \log p = -56{\cdot}605 + 3{\cdot}8015T - 0{\cdot}10458T^2 + 0{\cdot}003321T^3 - 0{\cdot}00005102T^4.$$

In the measurements at $\theta = 244{\cdot}70$ and $\theta = 243{\cdot}22$, the deviations are greater than might have been expected, and it is assumed that some unexplained experimental error must be present. A redetermination of the boiling-point gave the value $T = 20{\cdot}38°$ K.

A. F.

958. 0° *or* 20°, *or* 0° *and* 20°. [*Pure Normal Temperature or Normal Temperature and Standard Temperature.*] **F. Plato.** (Zeits. Instrumentenk., Beib. 9. 10. pp. 49–54, May 5, 11, and 12. pp. 61–66, June 15, 1918.)—So long as instruments exist whose readings are dependent on temperature, there will be a need for fixing a particular temperature for reference. When the choice of this temperature is restricted to a select circle, then we speak of a standard temperature, but when State recognition is given, or international sanction is obtained, then the standard becomes a normal temperature. A large number of normal temperatures are in existence, but of these only two (of French origin) are not arbitrary, namely: the temperature of melting ice, and 15° C. (proposed by Gay-Lussac as the average temperature of the earth). The present paper contains a discussion of the various temperatures in the neighbourhood of 15° C. which have been proposed from time to time. For many purposes 20° has been found very convenient, and the advantages together with the drawbacks are dealt with at some length. The discussion includes that of other units in different systems. Section 1 considers the temperature of melting ice as a natural phenomenon. Section 2 treats the latter from the standpoint of requiring no thermal measure for its determination. In Section 3 its independence with respect to temperature scales is examined. Here the various thermometric scales come under review. In Section 4 the temperature of melting ice as a starting-point is shown as a safeguard against sign errors. In Section 5 the possibility of international agreement to this temperature as normal temperature is discussed. The different national temperatures are here described. Following this comes an exhaustive discussion on the question of adopting 20° C. as a special standard temperature which would be especially beneficial to industry. H. H. Ho.

959. *Isothermals of Monatomic Substances and their Binary Mixtures. XIX. Vapour Pressures of Neon between the Boiling-point and the Critical Point.* **P. G. Cath** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 20. 8. pp. 1160–1162, 1918. Comm. No. 152*b* from the Phys. Lab., Leiden.)—Using the same apparatus and method as in the case of helium the authors have determined the vapour pressure of neon, and have obtained the following results :—

θ =T−273·09.	T.	p in Atmos.	p Calc.	Difference in Degrees.
− 248·67° C.	24·42° K.	0·4256	0·4330	+ 0·06
248·51	24·58	0·4276	0·4476	+ 0·15
247·49	25·60	0·5942	0·6445	+ 0·25
246·66	26·43	0·7963	0·8350	+ 0·16
245·88	27·21	1·0094	1·052	+ 0·14
245·68	27·41	1·0740	1·114	+ 0·17
243·69	29·40	1·888	1·895	+ 0·01
241·77	31·32	2·980	2·984	+ 0·01
240·25	32·84	4·178	4·136	− 0·04
236·82	36·27	7·970	7·909	− 0·05
233·60	39·49	13·213	13·300	+ 0·04
231·71	41·38	17·428	17·474	+ 0·01
229·26	43·83	24·305	24·25	− 0·02
228·66	44·43	26·049	26·09	+ 0·01

These results may be represented by the equation—

$$T \log p = -65{\cdot}061 + 2{\cdot}8191T + 0{\cdot}01118T^2.$$

A. F.

960. *The Specific Heat at Low Temperatures.* IV. *Measurements of the Specific Heat of Liquid Hydrogen. Preliminary Results on the Specific Heat of Solid Hydrogen and on the Heat of Fusion of Hydrogen.* **W. H. Keesom** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 20. 7. pp. 1000–1004, 1918. Comm. No. 153*a* from the Phys. Lab., Leiden.)—The determinations were carried out as in the case of nitrogen [Abs. 1133 (1916)]. The results obtained were as follows :—

Quantity of Hydrogen in Gm.	Mean Temperature.	Specific Heat of Hydrogen in cal. 15° per degree K.	Atomic Heat in cals. 15° per degree K.
2·89	16·03$_5$	1·87	1·88
3·17	15·81	1·70	1·71
3·17	16·80	1·84	1·85$_5$
3·52	14·71	1·67	1·68
3·52	15·38	1·78	1·79
3·50	14·82$_5$	1·74	1·75
3·50	16·30	1·85	1·87
3·50	17·63	1·99	2·00
3·50	18·67	2·08	2·09
3·50	19·41	2·18	2·20
3·50	20·11	2·24	2·26
3·51	15·24$_5$	1·84	1·82
3·51	16·37	1·90	1·89
3·51	17·37$_5$	1·99	1·98
3·51	19·07	2·17	2·16

Preliminary determinations of the specific heat of solid hydrogen gave at T = 12·55° K., the value 0·64. For the heat of fusion per gm. of hydrogen the mean value of 15 cals. (15°) was obtained. A. F.

961. *The Measurement of very Low Temperatures.* XXVIII. *Comparison of the Platinum and the Gold-resistance Thermometers with the Helium Thermometer.* **P. G. Cath, H. K. Onnes,** and **J. M. Burgers.** (K. Akad. Amsterdam, Proc. 20. 8. pp. 1163–1176, 1918. Comm. No. 152*c* from the Phys. Lab., Leiden.)—The variation with temperature of the resistance of Au and Pt has already been investigated down to liquid-air and at liquid-hydrogen temperatures.

The present contribution refers particularly to the region 55° K. to 27° K., which has not hitherto been studied, together with some measurements outside this range by the aid of which it is possible to give data concerning the resistance of Au and Pt running without intermission through the temperature range 15° K. to 273° K. Nernst [Abs. 624 (1911)] has proposed a linear function to connect the difference between two platinum thermometers at low temperatures. A relation of the second degree which was proposed by Henning gave better agreement, but Holst, who tested it on an extensive experimental material, found that while the agreement was satisfactory above 80° K., it failed at liquid-hydrogen temperatures.

The data given in this paper show that, when the difference between the two resistances is plotted against temperature, the curve has a pronounced bend over at the lower temperatures (below 70° K.). Henning's formula is applicable down to 50° K., while the straight line proposed by Nernst is quite inapplicable at the lower temperatures.

Another quadratic interpolation formula is required for the representation of the results at liquid-hydrogen temperatures (20° K. to 14° K.). E. G.

962. *The Entropy of a Metal.* **H. S. Allen.** (Phys. Soc., Proc. 30. pp. 215–220, June, 1918.)—An expression for the entropy of one gm.-atom of a substance in the solid state has been given by Ratnowsky. In 1916 the author gave the correct form of the approximation required for high values of the absolute temperature in terms of Bernoulli's numbers [see Abs. 902 (1916)]. The data required for testing the formula have been supplied recently by Lewis and Gibson, who have given values for the entropy of the elements under the condition of constant volume, and also under constant pressure. These values were deduced from observations on the specific heat assuming the truth of the heat theorem of Nernst, that the entropy of every actual substance in the pure state is zero at the absolute zero of temperature. It is found that the formula of Ratnowsky gives values for the entropy of a solid in very close agreement with those obtained by Lewis and Gibson. The hypotheses assumed in the theory of Ratnowsky are discussed, and the conclusion is drawn that these are probably justified as being at least approximately true. AUTHOR.

963. *A Method for the Determination of the Relation between Vapour Pressures and their Corresponding Temperatures at Pressures of Less than Five Millimetres.* **W. R. Ham, J. C. Churchill, and H. M. Ryder.** (Frank. Inst., J. 186. pp. 15–28, July, 1918.)—For the description of the apparatus reference must be made to the original. The authors find that the actual mathematical representation of the relation between vapour pressures and temperatures, either by means of equations based on theory or by purely physical forms, has not as yet been satisfactorily accomplished. A. F.

964. *On the Saturated Vapour-tensions of Tetratomic Bodies.* **E. Ariès.** (Comptes Rendus, 166. pp. 802–805, May 21, 1918.)—To the author's knowledge, data only exist for three tetratomic bodies which can be used in his formula for the vaporisation tension of liquids. These are ammonia, acetylene, and phosphorus trichloride. The vapour-tensions of liquefied ammonia given by Regnault merit confidence, having been confirmed later by Pictet. Using these data in connection with the critical constants determined by Jaquerod, a value of 5/6 should be adopted for n in the formulæ, which therefore become :

$$T = 1 + \frac{(1-\tau)(0{\cdot}84-\tau)}{\tau^2+1}; \quad \pi = \tau^{2+5/6} zx, \quad x = \left[1 + \frac{(1-\tau x 0{\cdot}84-\tau)}{\tau^2+1}\right]\tau^{1+5/6}$$

A table of results is given, showing that the agreement between observed and calculated results is most satisfactory. For acetylene, unfortunately, the results are inconclusive for the temperatures at which data are available, but show a tendency towards agreement at the higher temperatures. Further experimental data are here awaited. In the case of phosphorus trichloride the critical pressure necessary for use in the vapour-tension formulæ is unknown, but, using experimental data for the vapour-tension, the author calculates the critical pressures for the various observations and concludes that it should be in the neighbourhood of 67 atmos. From this he opines that the tension of its vapour should be represented by the above formula. The law of corresponding states thus appears to be followed by the saturated vapour, tensions of tetratomic bodies. H. H. Ho.

965. *The Viscosity of Liquefied Gases.* X. *Viscosity of Liquid Hydrogen.* **J. E. Verschaffelt.** (K. Akad. Amsterdam, Proc. 20. 7. pp. 986–990, 1918. Comm. No. 158*b* from the Phys. Lab., Leiden.)—The author has redetermined the value of the viscosity of liquid hydrogen [Abs. 1080 (1917) by the oscillating method and finds, at the temperature 20·43° K., the value $\eta = 0{\cdot}000130$ with an accuracy of about 1 %. A further experiment was made from which a preliminary value could be derived for the viscosity of the hydrogen vapour. This was found to be $\eta = 0{\cdot}000010$. A. F.

966. *The Joule-Thomson Effect and the Equation of State for Gases at Small Pressures.* **M. Jakob.** (Ann. d. Physik, 55. 7. pp. 527–544, June 21, 1918. From the Physikal-Techn. Reichsanstalt.)—From Planck's partial differential equation

$$\frac{10^4 T^2}{427}\left(\frac{\partial \,.\, v/T}{\partial T}\right)_p = (c_p)_0 \left(\frac{\partial \Delta}{\partial p}\right)_T,$$

[see Abs. 126 (1917)] the equation of state of a gas may be derived if, besides its specific heat $(c_p)_0$ for $p = 0$, the integral Joule-Thomson effect Δ for an infinitesimal pressure is given as a function of the initial pressure p(kg./cm.^{2}) and temperature T, also an isothermal of the state is given for the determination of the arbitrary integration function when the integration is made with respect to T. From the throttle experiments of Bradley and Hale, and of Noell for air, the empirical equation $(\partial\Delta/\partial p)T = Ap^3 + Bp^2 + Cp + D$ was obtained, wherein A, B, C, D are simple rational functions of T. From these equations and an isothermal by Amagat and Holborn and Schultze [see Abs. 92 (1916)] follows the equation of state : $v = RT/10^4 p + A'p^3 + B'p^2 + C'p + D' + E'T$, where R is the gas-constant, and A′, B′, C′, D′ are similar functions of T as A, B, C, D. E′ is a determined rational integral function of p. The author has found this equation of state valid at high pressures, *e.g.* at −140° C. up to 30 atmos., at −80° C. to 200, at 0° to 700, at 200° to 1000 atmos. The relations at very low pressures have been considered, and for $p = 0$ the following equation evolved: $\partial(pv)/\partial p = D' = -191310/T^4 + 10229/T^3 - 147{\cdot}63/T^2 + 0{\cdot}08978/T + 0{\cdot}00065708$. This equation is established in the present paper and compared with known experimental data. This comparison gives a sharp criterion as to the validity of the above equation of state for very small pressures, and between what temperature limits. It is shown that the last equation holds good for other gases after the introduction of the necessary data. Section 2 of the paper deals with the inadmissibility of the identification of an ideal and of a real but infinitely diluted gas. Section 3 develops the general form of the equation of state of a real gas. In Section 4 the equations of state and the Joule-Thomson effect according to van der Waals and Berthelot are considered. The Joule-Thomson effect of infinitely dilute air according to theory and experiment, forms the subject of Section 5. Section 6 deals with the derivation of a real but infinitely dilute gas from Mariotte's law. In Section 7 the Joule-Thomson effect of other gases is calculated from that of air, according to the method of corresponding states. The equation of state is found to hold good for very low pressures as for very high, and so to be of general applicability. H. H. Ho.

967. *Proof of the Assumptions underlying the Thermodynamic Potentials.* **M. B. Weinstein.** (Ann. d. Physik, 55. 7. pp. 497–526, June 21, 1918.)—A large number of methods have been worked out and applied to the proof of the fundamental form of the thermodynamic potentials. The author has found, however, that rigid proofs are still desired in many directions and that a considerable amount of objection can be raised against previous methods. In the present paper the author develops theoretical methods by which these difficulties may be overcome. Current methods are first discussed. A certain amount of support for the known assumptions with respect to thermodynamic potential has been afforded by the van't Hoff gas laws for dilute solutions. So far it is believed that these laws may be derived from thermodynamic considerations. That these laws only concern osmotic relationships is clear, and, at the outset, the paper contains a short discussion of some of the attempts which have been put forward from the thermodynamic standpoint. It is shown that from purely thermodynamic considerations the proportionality between osmotic pressure and concentration cannot be established; also that the same holds for the temperature relation, and, generally, processes involving diffusion are irreversible. Osmotic mechanism must, therefore, be regarded as irreversible. Section 2 of the paper deals with the case of electrolytes, where, alone, the connection between the Arrhenius conductivity laws is capable of treatment by the thermodynamic equations. In Section 3 it is found that the thermodynamic theory of e.m.f. is still the best in accord with experience. In Sections 4 and 5 the author evolves further formulæ for the fundamental equations of equilibrium. Section 6 contains further considerations of thermodynamic potential. The comparison of dissociation in solution mixtures with that in simple solutions is discussed in Section 7.

The treatment of the subject is mathematical throughout. H. H. Ho.

968. *Structure of the Phase-Space of a partially Periodic System.* **P. S. Epstein.** (Preuss. Akad. Wiss. Berlin, Ber. 23. pp. 435–446, 1918.)—One of the greatest obstacles to the development of the quanta theory was removed in 1915, when simultaneously Planck [Abs. 348 (1916)] and Sommerfeld discovered methods whereby the above theory could be extended to systems with several degrees of freedom. Planck started by considering the ideal phase-space of a system expressed in Cartesian coordinates, and showed how this must be divided by means of special singularities into regional elements of content h^f (where h denotes the Planck active quantum). On the other hand, Sommerfeld investigated the retardation of a defined individual motion of the system, and solved the problem as to the particular conditions which must exist for the system to become statical. Certain defects contained in Sommerfeld's conditions were removed by Schwarzschild and the author for a fairly comprehensive class of motions known as partially periodic. There now arises the question as to how far this latter distribution agrees with that of Planck. In all special cases hitherto treated by both methods complete agreement has been found, yet both processes appear to be incomplete in Schwarzschild's opinion. Accordingly in the present paper it is shown that Planck's results for a partially periodic system are quite general, and lead to the Schwarzschild-Epstein specialisation of Sommerfeld's quanta hypotheses. Accordingly the results for special cases are already contained in Planck's work of 1915. Section 2 of the paper deals in detail with partially periodic motions. Sections 3 and 4 consider Planck's work at some length. In Section 5 systems with coherent or degenerate degrees of freedom are examined, and the final Section 6 discusses particular species of singularities. H. H. Ho.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

969. *Electron Theory of Metals.* **T. Wereide.** (Ann. d. Physik, 55. 8. pp. 589–607, June 28, 1918. Paper read before the Physical Soc., Christiania.)—Drude's formula for electric conductivity $\chi = 0{\cdot}5e^2nl/mv$ appears to be undoubtedly valid if the correct values of the quantities concerned are substituted. Using the most recent results of Lenard, the three unknown quantities n, l, and v can be eliminated, and a formula is then obtained involving ν, ϵ and α, where ν is the oscillation frequency of the atom, ϵ the mean number of electrons emitted from the atom per sec. and α is the absorption coefficient of the atom. The coefficient α is connected with Lenard's coefficient a by the relation $a = c\alpha$, where c is the number of atoms per cm.^{3}. Theory gives then the following formula for the electric conductivity: $\chi = [e^2\epsilon/6c\alpha^2] . (e^{h\nu/kT} - 1)/h\nu$, with a corresponding formula for the heat conductivity. From the formula it is seen that for high temperatures the electric resistance is approximately proportional to the absolute temperature, and the variation of resistance depends in the first instance on the energy variation of the material. The resistance approximates to a limiting zero value at low temperatures. The formula is also in agreement with various results of Schimank and Benedicks. From Lenard's work the order of magnitude of the quantity α and also of the other quantities involved can be calculated. The formula then gives results approximating to the values to be expected from other considerations. A. W.

970. *On the Divisibility of Electricity.* **F. Ehrenhaft.** (Ann. d. Physik, 56. 1. pp. 1–80, July 5, 1918.)—This very long and comprehensive paper is divided into 13 sections and supplemented by an appendix. The first 4 sections deal with the various opinions and theories which have been expressed as to the existence of an indivisible atom of electricity of fixed magnitude such as the electronic theory postulates. These sections are: (1) Introductory; (2) Fundamental assumptions; (3) Divergent conclusions from the rising or falling velocities of metallic or liquid particles in the homogeneous electric and gravitational fields; (4) An eventual law of integral multiples in gases. In the next 7 sections the author attempts to give a solution for the various divergent hypotheses. These he considers from the standpoints of absolute and relative atomistics. The former he subdivides into (*a*) a mechanical and statistical part which includes the sections:—(5) dealing with experimental work on metals, oils, and non-spherical objects; (6) on the spherical shape and density of the observed particles; and (*b*) an optical part which deals with: (7) diffraction by the particles (an optical determination of size); (8) size determination for still smaller materials; (9) supplementary proof of the spherical shape; (10) the electric charges on spherical silver particles and on other particles (such as of oils). Under relative atomistics the subject is discussed in Section 11 as to whether the so-called law of integral multiples in gas permits of a positive statement being made as to the nature of electricity. Section 12 summarises the results as follows:—The determination of the electricity quanta is in principle that of the magnitude, *i.e.* weight, of the charge carrier of the test substance. Four independent methods for this determination have been discussed, namely: (I) the mechanical method; (II) the statistical thermodynamical process in which the Brownian movement affords a working means without any assumption as to form and density of the test substance; (III) the optical way; (IV) the radiation process. Of these four modes of measuring submicroscopic magnitudes numbers 1, 2, and 4 agree completely, while the statistical-thermodynamic process gives too large a radius for metallic bodies and too small for oils, if a Loschmidt number $N = 60{\cdot}5 \times 10^{22}$ be assumed. The theoretical quantum of $4{\cdot}7 \times 10^{-10}$ e.s. unit has not been found. The smallest charge, of the order 3×10^{-13} e.s. unit, has been found by Parankiewicz for the case of deep-blue mercury particles formed by evaporation in the purest argon. Neither from charges on metallic nor on dielectric test substances could information be obtained as to the nature of electricity, nor could a lower limit be detected in the case of the actually established charges. It is proved that the supposed integral relationship of charges is purely of arithmetical origin and has nothing to do with fundamental questions as to the nature of electricity.

The conclusion is drawn that for the case of electric atomistics the electric atom, according to all experience, can only consist of a charge which is even smaller than 1×10^{-10} e.s. unit. It is, however, not excluded that further research may show the possibility of the existence of such an atom in a region of still smaller conditions of charge. The appendix contains some remarks on the methods of measurement employed. H. H. Ho.

971. *Corpuscular Nature of Electricity.* **R. Bär.** (Archives des Sciences, 46. pp. 47–48, July, 1918. Paper read before Soc. Suisse de Physique.)—After discussing the opposing views of Millikan and Ehrenhaft regarding the discrete nature of electricity, that is, regarding the existence or otherwise of electrical quanta, the author gives a table containing the results of experiments on electrified microscopic particles of aluminium. These experiments were carried out on the lines of Millikan's, in which small charged particles fall under the action of gravity plus or minus an additional electrical force.

The table of results is strong evidence in favour of Millikan's view of "electrical quanta." A. B. W.

972. *On Maxwell's Relation between the Refractive Index and the Dielectric Constant and on a Method for the Estimation of Ionic Charge in Crystals.* **M. Born.** (Preuss. Akad. Wiss. Berlin, Ber. 29. pp. 604–618, 1918.)—The explanation given by the dispersion theory of the invalidity of the Maxwell relation between the refractive index n and the dielectric constant D, $n^2 = D$, has received complete confirmation through the researches of Rubens. After proving the existence of special oscillations in the long-wave ultra-red by means of the method of residual rays, he has established up to wave-lengths of 300 μ that the refractive index of a large number of solid bodies after the passage by the ultra-red absorption band was almost exactly the value $\sqrt{D}$. Madelung has connected the theoretical significance of the absorption band in the ultra-red with the oscillations of the charged atoms (ions) of the crystal lattice, and derived relations between the frequency, on the one hand, and the elastic constants and specific heat on the other. [See Abs. 626 (1913)]. Madelung has also attempted to estimate the ionic charge by his theory, and to obtain an approximation of the character of the quantum element. An exact evaluation of the frequency of the long-wave absorption bands from the elastic or thermal data is, however, not possible without

special hypotheses as to the nature of the molecular forces. Reference is made to the author's book on the "Dynamics of the Crystal Lattice," where a method is given for determining the course of the refractive index when the positions of all atoms and electrons are known together with the forces acting between them. Since the region of the residual rays is completely isolated from that of anomalous dispersion, the course of the refractive index in the ultra-red for diatomic crystals is completely independent of the molecular forces and only determined by the masses and charges of the atoms. In this way a connection has been found between the wave-length of the ultra-red special oscillation and the difference $D - n_r^2$, where n_r is the approximate value of the refractive index between the short waves and its long-wave ultra-red special oscillations. This deviation from Maxwell's law affords data for the determination of the frequency of the lattice oscillations, and, since there occurs in the new relation the product of the wave-length and the atomic charge, it becomes possible to estimate this charge by comparison with the observed wave-lengths of the residual rays. The result shows that the charge of a motion in the solid body is of like order to that in electrolytes, *i.e.* is equal to the Faraday constant F. The author gives the calculation for 8 types of regular lattice, which includes a large number of crystal structures known by means of Röntgen-ray measurements. Section I contains a description of the lattice. Section II derives the dispersion formula in the ultra-red. Tables of results are given for rock-salt, sylvine, potassium bromide, potassium iodide, and fluorspar, where the lattice as also the wave-length of the residual rays are known; and for thallium chloride, thallium bromide, thallium iodide, silver chloride, and silver bromide where the refractive index and dielectric constant, but not the lattice structure, are known. H. H. Ho.

973. *Electromagnetic Field of an Electric Doublet in a Biaxial Anisotropic Medium.* **M. Brillouin.** (Comptes Rendus, 166. pp. 412–415, March 11, 1918.)—The author briefly indicates the extensions so far obtained of the mathematical investigations of a former paper [Abs. 87 (1918)]. The components of the field are found to be linearly expressible in terms of the fourth derivatives with respect to the time and the coordinates, of a single function Φ of x,y,z,t, which reduces, for points near the centre of the doublet to the form $\phi(x,y,z)f(t)$, homogeneous and linear in x,y,z. The integrals of the equation, like those of the equation of sound, are derivable for any number of sources from the equation for any one of them, but are, in general, very complicated. Some tentative steps are indicated towards obtaining definite solutions, including the determination of the amplitudes, in a comparatively simple case, by the aid of what appear to be plausible assumptions.

G. W. de T.

974. *Motion of Continuous Distributions of Electricity.* **H. Bateman.** (The Messenger of Mathematics, New Series, No. 549. Vol. 46. pp. 186–145, Jan., 1917.)—The author's object is to determine whether or not the medium to be assumed for the propagation of light and electromagnetic disturbances in accordance with the relativity theory differs essentially from the substance commonly associated with the electrons. He starts with the fundamental equations of the electron theory, simplified by the assumption that in the ether the electric density is vanishingly small, **V** being assumed to be finite and to satisfy Cunningham's [Abs. 124 (1910)] relativity condition for ether velocity. Dealing with electromagnetic fields previously investigated by himself or others, he obtains results with respect to the character of tubes of force which are in accordance with generally accepted results. Regarding a tube of electric force as a chain of infinitesimal doublets, radiation seems to be determined by a variation in the duration of projection of point charges or doublets as well as a change in velocity of a point charge. [See also preceding Abs.] G. W. DE T.

975. *Structure of an Electromagnetic Field.* **H. Bateman.** (Nat. Acad. Sci., Proc. 4. pp. 140–145, May 15, 1918.)—The author summarises here the mathematical procedure which he has developed in various papers contributed to mathematical journals, and indicates the physical points of view involved. He starts by adopting as an elementary solution of the fundamental equations of the electron theory—

$$\mathbf{H} = \text{rot}\,\mathbf{A},\ \mathbf{E} = -1/c\,.\,\partial\mathbf{A}/\partial t - \nabla\Phi,\ \Phi = \text{div.}\,\mathbf{A} + 1/c\,.\,\partial\Phi/\partial t,$$

$$\rho = -1/c\,.\,\partial\Psi/\partial t,\ \rho\mathbf{v} = c\nabla\Psi,\ \text{where}$$

$$\mathbf{A} = c\int_{-\infty}^{a} f(\tau)\nabla \log[\mathbf{s}\,.\,\mathbf{r} - c(t-\tau)]d\tau,$$

$$\Phi = -\int_{-\infty}^{a} f(\tau)\partial/\partial t \log[\mathbf{s}\,.\,\mathbf{r} - c(t-\tau)]d\tau\,;$$

s being a unit vector depending on τ, **r** the radius vector from the point $\xi(\tau)$, $\eta(\tau)$, $\zeta(\tau)$, to the point x, y, z, a being defined by the equation $[x-\xi(a)]^2 + (y-\eta(a)]^2 + z-\zeta(a)]^2 = c^2(t-a)$ for $a \ngtr t$, and $\Psi = c/\nu . f(a)$, where $\nu = \xi'(a)[x-\xi(a)] + \eta'(a)[y-\eta(a) + \zeta'(a)[z-\zeta(a)] - c^2(t-a)$. This represents an elementary field in which concentrated electric changes are created and travel, with the velocity of light, along straight lines whose directions are specified by the different values of **S**, the creation being accompanied by the firing out in all directions of a compensating amount of electricity, which provides an elementary "ether" which is the seat of the electromagnetic field of the concentrated charge. Such a charge and its elementary ether lie at any instant on a sphere whose centre is the point of origin of the charge. If this point move at less than the speed of light the different spheres bearing the electricity existing at time t do not intersect, and if $f(a)$ is never zero there will be a sphere through each point of space, so that the elementary ethers will fill all space; but if $f\,(a)$ be sometimes zero, *e.g.* for $a < a_0$, then they will not fill all space. The author observes that it can be shown that the field of an isolated electric pole moving with speed less than that of light can be regarded as the limit obtained by subtracting one elementary solution from another differing only in the value of **S**. Then ρ and $\rho\mathbf{V}$ vanish except near concentrated charges, and the superposition of the two elementary ethers accordingly gives an ether in the ordinary sense. The field is then one in which concentrated charges of opposite signs are continually produced by a separation process analogous to that described by Heaviside in 1901. Since the energy flow is rectilinear solenoidal, it may be regarded as kinetic. Fields in which electricity or magnetism travels with less speed than that of light are to be regarded as consisting of elementary fields so superposed as to cancel nearly all concentrated or magnetic charges. If this cancelling be not complete, ρ and $\rho\mathbf{V}$ will be derivable from a function ψ which satisfies the wave-equation at points not occupied by matter. It is consistent with this view that an electric charge which has been moving for all time along a rectilinear path with the velocity of light should have no surrounding field [Abs. 288 (1917)] for charges arising only from separation, and its ether being created in the process, the charge will have no ether to support a field. Some of the logical difficulties in the ideas of both contact and distance actions can be avoided from this point of view, since an electric charge at P produces an effect at Q simply because, either a portion of the charge itself, or a portion of the simultaneously created compensating charge, actually goes to Q and helps to produce the particle acted upon, or rather the entity representing the particle at the moment considered. The paper contains some further mathematical considerations of interest. G. W. DE T.

DISCHARGE AND OSCILLATIONS.

976. *The Action of an Induction Coil with an Interrupter of Recent Type.* **O. M. Corbino.** (N. Cimento, 15. pp. 10–21, Jan.–Feb., 1918.)—This is in the main a mathematical paper in which the object is to illustrate the working of an induction coil as it has been recently employed, *i.e.* with frequent interruptions, without a condenser, but with inversion of magnetisation after each break of the primary current. A. E. G.

977. *Using Induction Coil with Inversion of Magnetisation in the Primary.* **G. C. Trabacchi.** (N. Cimento, 15. pp. 22–33, Jan.–Feb., 1918.)—This paper describes experiments which help to confirm the conclusions arrived at theoretically by O. M. Corbino [see preceding Abs.]. The following are the main points considered :—The law of variation of current through an X-ray tube and the tension at its terminals during each discharge. This is accomplished by an examination of the secondary current, the results of which are illustrated in a series of diagrams ; and the examination of the secondary voltage which is also illustrated diagrammatically. The tubes investigated are the Pilon and the Coolidge tube. With the former, at the beginning of the discharge the voltage mounts briskly to its max. value and decreases but little or not at all, according to the duration of the pause (curves showing the effects of long and short pauses are given) until at the moment of the fusion with the "make" voltage, when a trifling increase occurs. After about ¼ of the period the voltage decreases quickly to zero. With the Coolidge tube the voltage during each discharge varies considerably. A. E. G.

978. *Refraction and Absorption of Water for Electric Waves about One Metre in Length.* **E. Rückert.** (Ann. d. Physik, 55. 2. pp. 151–176, May 10, 1918. Dissertation, Greifswald.)—An experimental research which may be summarised as follows. (1) A method has been developed which, by means of a system of parallel wires and plate bridges, leads to a determination of both the refractive index and the absorption. (2) The refractive index of water at 17° C. for electric waves from 250 cm. to 57 cm. long. has (within the limits of experimental errors) the constant value $n_{17} = 8{\cdot}964$. (3) Below waves of 200 cm. a region of absorption of pure water begins to show itself, and finally increases considerably with diminishing wave-lengths. [See Abs. 1337 (1913).] E. H. B.

979. *Stability of Oscillations in a Particular Oscillating Circuit.* **J. Bethenod.** (Rev. Gén. d'Él. 4. pp. 85–86, July 13, 1918.)—The circuit under consideration consists of a capacity (C) and a reactive coil (L_1R) connected at their points of junction to a battery of resistance R_0 through

leads containing an arc or vacuum tube having a voltage-current characteristic $E = f(I)$. The solution of the equations for this circuit shows that if the resistance $\rho (= \Delta E/\Delta I)$ of A satisfies the relations $\rho > R_0 + R$ and $\rho = R_0 + L/(CR)$, undamped periodic oscillations are produced with a frequency $f = (1/2\pi)\sqrt{[(L - CR^2)/(CL^2)]}$. This has a real value if $L > CR^2$. It would appear probable that sustained oscillations could be maintained by a suitably regulated arc at A, but this has not yet been proved by experiment. The action would be assisted by connecting a large condenser across the battery, so as to provide an easy path for the oscillations. A. J. M.

980. *Excitation of Oscillatory Circuits.* **H. Wiesinger.** (Ann. d. Physik, 55. 6. pp. 401–475, June 14, 1918.)—Discusses the method of setting a circuit in oscillation by interrupting the current flowing in the circuit, with special reference to the efficiency of the method, which it appears is in general very small. The analysis of the phenomena at the "break" by means of a Braun tube shows that it is the spark occurring at the break which causes the low efficiency of this method of excitation. The Braun tube method was also used to investigate the effect of various arrangements on the occurrence and character of the spark occurring at the break, and criteria were thence deduced for obtaining the best results possible by this method of excitation. Following Heaviside and Wagner and introducing certain simple assumptions, a mathematical theory has been developed which agrees with the experimental results obtained. In conclusion the results are applied to the induction coil. The paper includes a large number of diagrams and photographs in which its chief interest lies. A. W.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

981. *Weston Normal Cell Comparisons.* **J. Obata.** (Electrot. Laborat. Tōkyō, Researches, No. 70. pp. 1–11, May, 1918.)—The first comparisons between the standards of e.m.f. of the Electrotechnical Laboratory of Japan, of those of the National Physical Laboratory and of the Bureau of Standards, Washington, were made in 1914 by means of 4 cells of the National Physical Laboratory and 2 of the Bureau of Standards. In the autumn of 1916 a second series of comparisons were made with other cells, and in 1917 a third series. Allowing for small changes in the cells it appears highly probable that the standards of e.m.f. of the three institutions agreed on all occasions within 1 part in 100,000. F. E. S.

982. *Dielectric Constants of Mixtures.* **W. John.** (Ann. d. Physik, 55. 4. pp. 299–336, May 24, 1918.)—The mixtures here dealt with are mixtures of solid bodies and air. The solid bodies were either in the form of small spheres or cubes. The value of the small index u (occurring in Wiener's modification of the Lorentz-Lorenz formula) was investigated for spheres and cubes in isotropic arrangement, as a function of the mixture ratio, and it was found that the two quantities showed a marked dependence on each other. For cubes the dependence was not found to be the same as for spheres. With spheres at comparatively large distances apart the value of u obtained was, within the limits of error, 2, which agrees with the Lorentz-Lorenz formula. With spheres closer together the value of u was greater than 2. By means of a formula deduced from Rayleigh's theory, the values of u for spheres could be calculated directly, and the values thus obtained were found to correspond with the observed values. In general the agreement was within the limits of error. The results obtained with cubes were not so consistent as those obtained for spheres, but on the whole were in agreement with theory. A. W.

983. *Braun Tube with Glowing Kathode.* **C. Samson.** (Ann. d. Physik, 55. 8. pp. 608–682, June 28, 1918. Dissertation, Berlin.)—The first part of this paper describes, with diagrams, the construction of a Braun tube with a glowing kathode consisting of a tungsten spiral, specially mounted in a small iron cylinder. The anode consists of an Al cylinder, whose end nearest the kathode is closed by a nickel plate through which a central hole is bored about 1 mm. in diam. The rest of the tube presents no new features. Several tables are given relative to the various potentials and filament currents employed. The second part of the paper describes a method of employing the tube for the measurement of high alternating potentials. As a test of the method, the sparking potentials between various electrodes were determined and compared with the results obtained by Müller. The third part of the paper gives a description of an investigation of the potential and current-strength distribution in a Coolidge tube. It appears from the results obtained that momentary current-strengths of so much as 2 amps. may traverse Röntgen-ray tubes of this type. A. W.

984. *A Fundamental Effect connected with Thermo-Electricity and the Thermal Conductivity of Metals.* **C. Benedicks.** (Ann. d. Physik, 55. 1. pp. 1–80, May 2, 55. 2. pp. 103–150, May 10, 1918.)—In these papers the author gives full details of numerous experiments he has carried out to establish the existence of an electric current in a homogeneous circuit when a temperature gradient obtains. Experiments on the effect of these currents upon the thermal conductivity of metals are also described. The chief points have previously appeared in various papers [Abs. 675, 1369 (1917), 106 (1918)]. L. L.

985. *Skin-effect in Tubular and Flat Conductors.* **H. B. Dwight.** (Am. I. E. E., Proc. 37. pp. 977–998, Aug., 1918.)—For experiments on high-frequency currents a tubular conductor is most suitable. The author gives a simplified method of computing the high-frequency resistance of a tube at moderately high frequencies. A formula is also obtained which enables the asymptotic value of the ratio of the h.f. resistance to the d.c. resistance to be written down at once. The results for tubes of various thicknesses are shown in the form of graphs which are adapted for everyday use. Similar methods are developed for the calculation of the skin-effect in strips. In this case it is better called the "edge effect." Although the calculations are not carried out to the case of very high frequencies, they indicate a useful method of arranging experimental results which have been obtained with strips of metal. A set of empirical curves is given from which approximate values of the high-frequency resistance can be found at once. A. R.

986. *Apparatus for Facilitating the Interpretation of Oscillograms obtained with the Braun Tube.* **G. C. Trabacchi.** (N. Cimento, 15. pp. 5–9, Jan.–Feb., 1918.)—The difficulty of obtaining a photographic registration by means of a rotating mirror is discussed. A photograph of the new apparatus is given, and the working of it is described in detail. There is also a sketch showing on the left the diagram of the primary current used with an X-ray (Corbino-Trabacchi model for direct current) apparatus, combined

orthogonally with a suitably chosen sinusoidal current; and on the right, the transformed tracing obtained with the apparatus described, in which the abscissæ are proportional to the time. A. E. G.

987. *Standard of Mutual Induction.* **A. Guillet.** (Journ. de Physique, 7. pp. 36–48, Jan.–Feb., and pp. 75–87, March–April, 1917. Paper read before the Soc. franç. de Physique.)—Describes in detail the method of construction of a standard mutual inductor with four lateral guard inductors. The calculation is given in full of the field due to a helical coil at any point along its axis. It is shown that the axial force Z at any point, the lines from which to the extreme coils of the helix, subtend angles of V_0 and V_n with the axis, is given by $Z = -3\pi n_1 (\cos V_n - \cos V_0)$, where n is the number of turns per unit length of the helix. The end correction for the force in the interior of a helix of given dimensions and of *finite* length is then found, and it is shown that for work of high accuracy the method of end correction by successive displacements of the inductive winding is not sufficiently close. J. W. T. W.

ALTERNATING CURRENTS AND MAGNETISM.

988. *Magnetic Susceptibility and Electric Resistivity.* **F. H. Loring.** (Chem. News, 117. pp. 229–231, July 5, 1918.)—The author attempts to correlate the susceptibilities of elementary substances with their resistivities. L. L.

989. *Normal State and Polarisation in Iron.* **E. Velander.** (Archiv f. Elektrot. 6. pp. 409–437, 1918.)—An investigation by a modified ballistic method on ring specimens of Swedish iron to study the effect of previous magnetic history on the permeability, and in particular at low inductions. The measured permeability for a given field may vary from three causes (apart from temperature changes, treatment, etc.), viz., (1) 50 % variations due to polarisation, *i.e.* the removal of the iron from a stronger magnetic field before the determination of the permeability. (2) 10 % changes due to accommodation effect: a series of reversals of the magnetising current being necessary before steady values are obtained. (3) 1 to 2 % errors due to incomplete magnetisation. The results obtained from these three points of view are represented in a series of curves and discussed. L. L.

990. *The Kerr-effect in Ferromagnetic Compounds.* **P. Martin.** (Ann. d. Physik, 55. 8. pp. 561–576, June 28, 1918.)—Dispersion curves of the Kerr-effect in Mn and Fe compounds have already been given [see Abs. 260 (1913)]. The present paper gives additional dispersion curves, and also rotation-temperature curves for a given wave-length. The observations were made by means of an arc light, a Du Bois monochromator and a large ring electromagnet giving fields up to 30–40 kilogauss. The substances examined were chiefly compounds of manganese, iron, nickel, and cobalt. In some cases the specimen was in the form of a powder pressed into pastille shape and polished. Results are given for three specimens of iron carbide. For the first of these (Fe_3C), a rotation-temperature curve shows the rotation to change gradually from —26′ at 0° to 0′ at 235° C. In the second and third cases, which contained 4·8 and 15 % of carbon respectively, the dispersion curves do not correspond with each other or with the first specimen. In all three cases there is fairly strong negative rotation, there being in the first case a maximum in the violet-blue and a minimum in the green-yellow ; in the other two specimens the singularities are displaced. For further details see original paper. G. E. A.

991. *A New Thermomagnetic Phenomenon.* **P. Weiss** and **A. Piccard.** (Comptes Rendus, 166. pp. 352–354, Feb. 25, 1918. Archives des Sciences, 45. pp. 329–335, May, 1918.)—In experiments on the magnetic behaviour of Ni a considerable rise in temperature was found to accompany the establishment of a magnetic field in the neighbourhood of the Curie critical temperature, while the suppression of the field gave rise to a corresponding cooling effect. Observations carried out at temperatures above the Curie critical point, in order to eliminate disturbance by previously existing magnetisation of particles of finite size, merely rendered sensible by the establishment of an external field, showed that the phenomenon was fully accounted for by the molecular-field hypothesis, by which it might have been predicted, and of which, therefore, it affords a striking confirmation. G. W. DE T.

992. *Pressure and Temperature Effects in Earth-current Measurements.* **S. J. Mauchly.** (Terrest. Magn. 23. pp. 73–91, June, 1918.)—Attention has several times been directed to relatively large currents between plates buried at different depths. Since the general existence of a vertical earth-current density of an order of magnitude much larger than the atmospheric-electric current density seems inconsistent with the principle of continuity of flow of electricity, it seemed desirable to attack first the problem of determining whether much of the so-called vertical-current density was not a phenomenon which owed its origin to spurious causes. The paper is largely descriptive of the precautions taken in these investigations to secure absolute reliability of results.

For the first part dealing with laboratory experiments they lead to the following conclusions :—

In a cell consisting of a non-conducting vertical tube filled with moist soil and supplied with a metal electrode near each end, there exists a component of the total e.m.f. whose direction tends to establish a kathode at the lower electrode regardless of the orientation of the tube ; *i.e.* the electrode under greater pressure tends always to be positive with regard to the other one. The magnitude of the effect varied with the nature of the electrodes and soil, but was always much in excess of the effects observed in simple salt solutions by Des Coudres.

Apparently the e.m.f. associated with difference of pressure at the electrodes increases with increased pressure-difference, although the law of variation is not known.

From the standpoint of earth-current measurements the important features to be noted are as follows :—

1. If the effect observed is representative of a general pressure-effect, it is of the order of magnitude necessary to account for the p.d.'s which have been found by various observers to be associated with vertical earth-currents.

2. The electrode at greater depth would by the operation of this effect tend to be permanently positive toward the upper one. This is in agreement with many recorded observations.

3. It is obvious that such an effect could not give rise to annual and diurnal variations.

In regard to the second part of the paper, which treats of out-of-door experiments on the relation between temperature difference and plate e.m.f. for a given pair of earth-plates and its bearing on measurements of the vertical earth-current, the author furnishes the following observations :—

1. The results, while strictly applicable only to the present installation, show the general nature and the order of magnitude of the effects to be expected when two earth-plates are subjected to a variable difference of temperature.

2. It appears that the natural plate e.m.f. between two electrodes buried at different depths in the same vertical may, on account of changes in their temperature difference, have a diurnal variation as large as that which has been ascribed by some observers to a true vertical earth-current. The diurnal variations observed by Brunhes at the Messeix mines certainly seem to be explainable on this basis.

3. Such effects as the observed prevailing tendency of earth-currents to flow from the foot of a mountain to its summit, and the marked relation between the activity of a volcano and the direction of current flowing up or down its sides, must certainly be considerably influenced by the effects of temperature difference on the plate e.m.f., and may perhaps not be as completely controlled by atmospheric-electric phenomena as has sometimes been supposed.

4. It is evident that care should be taken to have earth-plates buried well below the frost level of the soil.

5. Since the average diurnal variation for horizontal earth-currents as deduced from the results of measurements on lines not more than several km. in length is of the order of 0·001 volt/km. per hour, it is obvious that adequate provision should be made either for eliminating or taking account of temperature-difference effects.

6. It has long been recognised that non-polarisable electrodes are desirable for earth-current measurements. Such an electrode usually consists of a zinc or copper plate immersed in a solution of zinc sulphate or of copper sulphate, respectively, contained in a porous earthen vessel. When it is considered, however, that $Zn/ZnSO_4$ and $Cu/CuSO_4$ junctions have each a thermoelectric power of nearly a millivolt per degree, it would seem that the use of such electrodes is not, for short earth-current lines, a sufficient precaution for ensuring reliability of results, unless one can also be sure that temperature differences are negligible. E. O. W.

993. *Sudden Commencement of Magnetic Storms.* **S. Chapman.** (Phys. Soc., Proc. 30. pp. 205–212; Disc., 212–214, June, 1918.)—Three hypotheses have been advanced in the past, (1) that the sudden commencement of a magnetic storm is simultaneous over the earth; (2) that it travels with the speed of propagation of electromagnetic waves, and (3) that the time interval may amount to 3 or 4 minutes between remote stations, as concluded by Bauer. Another alternative is put forward by the present author. It has been suggested by Maunder and others that storms are occasioned by some solar agent which is transmitted along narrow, well-defined streams issuing from and rotating with the same period as the sun. Such a stream would first strike the earth on what is termed the "P.M. side," that is the side on which local time is P.M., and would take 30 seconds to pass right across to the other side. This suggested to the author the possibility that the commencement of a storm might show a progressive movement across the earth from the P.M. to the A.M. side with an extreme time interval of about 30 seconds.

Bauer's data for 15 storms have been grouped accordingly, having regard to the time of commencement of the individual storms, in order to test this hypothesis, and while no certain conclusion can be reached the results are suggestive and point to the desirability of working on these lines when more observational data of the required degree of accuracy are available. J. S. Di.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

994. *Control of Apparatus used in Radiology.* **T. Nogier.** (Archives d'El. Médicale, 26. pp. 241–246, June, 1918.)—It is pointed out that there is much laxity in the present method of supply of protective apparatus such as spectacles for X-ray work, and also of such measuring instruments as milliammeters. Two photographs are given to illustrate the points at issue respecting the former, and a diagram shows how much the readings obtained with two of the latter instruments varied from those of a standard pattern. The facts given show that it is important that steps be taken to rectify these faults or results dangerous to the operator, in one case, and the patient in the other, may be obtained. It is also mentioned that the Benoist radiochromometers often show from 1 to 3 degrees of difference for identical X-radiations, and the variation is still more marked when radiochromometers by different makers are compared.

It is suggested that apparatus used for protection or for measuring should not be sold except with a certificate of reliability obtained from a competent laboratory. A. E. G.

995. *Design of Electromagnet for Medical Purposes.* **H. du Bois.** (Elekt. Zeits. 39. pp. 173–175, May 2, and pp. 184–186, May 9, 1918.)—The article describes two models of electromagnets for medical purposes. The first is suitable for treatment of the stomach and the second and smaller one is for use principally for eye treatment.

The investigations deal with the best shape for the pole-pieces, and the effect of a proportional increase in all the dimensions of a magnet is examined. A number of measurements on both types are described, giving the distribution of the field and its capacity for attracting articles of different sizes and shapes at various distances from the pole-pieces.

The large model has an iron core 40 cm. long and a concave working end of 12 cm. diam. The core increases towards the rear and ends in a specially shaped flange extension, designed so that the section at all parts of the flange is the same as that of the core. An interrupter is provided for applying intermittent magnetic forces by short-circuiting the magnet coil. The intermittent effect is improved if the magnet core is laminated. The weight of the magnet is reduced to a minimum by using only three-quarters saturation of the core. The consumption is at the most 170 × 18 volt-amps. The total weight is 100 kg. The apparatus is supported on a swivelling arm that can be raised and lowered by a worm-wheel.

The smaller model weighs only 50 kg. and has a diam. of 8·5 cm. at the working end. A central cavity, 5 mm. in diam., contains a half-silvered 10-watt pea-lamp that can give 20 c.p. for a short time. This enables the eye to be strongly illuminated while operating. The filament of the lamp is toroidal in shape, in order that it may be affected to the smallest extent by the magnetic field. The presence of the cavity has only a very slight effect on the strength of the magnet. An illustration shows this model mounted for wheeling about. A flexible pole-projection consisting of fine wires may be attached. This projection, reducing in section to a point, may be used as a probe. The whole magnet and attachments are constructed in such a manner that they may be washed and sterilised.

The mathematical investigation and tests are applied to various shaped pole-pieces, one of which is concave with a parabolic cavity and another has an end similar to the letter L, which is specially adapted for exerting tangential tractive forces when drawn across the stomach.

Curves show the distribution of the field at various distances from the poles. In the case of the concave parabolic pole the field, at a certain excitation, decreases from the apex to a certain point from which it increases to a maximum. These maxima and minima give rise to a neutral region in which a magnetic substance remains in free suspension. The maxima and minima disappear when the concavity is filled by an iron plug. At short distances the strength of the magnet is thereby increased, a field of 36 kilogauss being obtainable with the larger model at 57,000 amp.-turns. Curves are also drawn showing the attraction of spheres of various materials at different distances. A. J. M.

996. *Diathermy: Use of Electric Current to raise the Temperature of the Body in Treatment of Disease.* **E. P. Cumberbatch.** (Inst. El. Eng., J. 56. pp. 349–351; Disc., 358–366, June, 1918. Abstracts in Electrician, 89. p. 876, April 19, 1918. El. Rev. 82. pp. 381–382, April 19, 1918.)—In diathermy heat is applied through the agency of an electric current of a special kind. When the current is passed through the body, part of the electrical energy is converted into heat as it overcomes the resistance of the tissues. The raising of the temperature of the tissues can modify their physiological processes and exercise a therapeutic influence over them in cases of disease. Further, it is possible by means of the electrical current to raise their temperature to a degree sufficient to coagulate them and so destroy their vitality. If the direct current is led through the skin by way of an electrode 1 sq. in. in area, a stinging pain is produced when it reaches a strength of 10 milliamps. and the pain is unbearable with a strength of 15 milliamps. To heat the skin appreciably a strength of 400 milliamps. would be required. An alternating current of low frequency would be equally unsuitable to produce diathermy, because it would cause violent and intolerable contraction of the muscles before it attained a density sufficient to develop heat. If, however, the frequency of the alternation is much increased the current loses its power to stimulate the excitable tissues. If it alternates 5000 times per sec. the muscles contract only feebly and the stinging sensation is not felt. If the frequency of alternation is increased to 50,000 per sec. there is no perceptible stimulation of the tissues. The density of the current can now be increased to a value which could not be tolerated in the case of direct or low-frequency alternating current, and only a feeble contraction of the muscles will be felt. If the frequency of the alternation is further increased to, say, 500,000 per sec. the current will lose all power to stimulate the tissues whatever its strength or density, and no sensation will be felt other than that of heat. Such a high-frequency current will not produce the electrolytic changes in the skin and underlying tissues which a direct current, if applied with too great a density, is liable to bring about, with the formation of blisters and ulcers. The probable explanation is that the high-frequency current is unable to cause a migration of ions and the formation of new chemical compounds possessing caustic properties at the poles. To produce a degree of diathermy sufficient for medical purposes an apparatus that can give 2·5 to 3 amps. is required. If a current of this magnitude is to be passed without danger through the body it must alternate at least 100,000 times per sec. An apparatus suitable for supplying such a current is described. A. E. G.

997. *Single-impulse (Instantaneous) Photography.* **R. Knox.** (Inst. El. Eng., J. 56. pp. 352–358; Disc. 358–366, June, 1918. Abstracts in Electrician, 80. pp. 876–877; Disc., 877, April 19, 1918. El. Rev. 82. pp. 382–383; Disc., 383, April 19, 1918.)—A brief account of the development of the method and apparatus for single-impulse radiography is given and a comparison is made of the exposures obtained from (*a*) a single-impulse outfit with mercury dip interrupter and (*b*) Siemens' impulse outfit. It is found that the exposures obtained from apparatus (*a*) are much shorter than those obtained from apparatus (*b*); the better quality of negatives obtained with set (*b*) has been attributed to the greater intensity of the discharge, but it is possible that the longer exposure is the real explanation of the difference. The Coolidge tube is undoubtedly the best and most reliable to use for this class of work because of its great flexibility, its durability, and the great ease of manipulation which it allows. With one tube any number of exposures may be made with the tube emitting rays of varying penetration. Though plates obtained with the screen are good it would be a great help in technique if it could be dispensed with altogether; at present this cannot be done because the apparatus is not powerful enough. An interesting set of experiments demonstrates the effect of passing the rays through the screen on to the film, and the gain in sharpness of the detail when the rays do not pass through the screen but through the glass to the film and on to the contiguous surface of the screen.

Plates exposed by the single-impulse method require to be developed for a longer time than those exposed by the time method. Care must be exercised to prevent fogging by the dark-room light or chemical fog from prolonged development: the plate should not be exposed to the red light for the first 3 to 5 mins. in order to obtain the max. photographic effect. It is indicated that it would be necessary to increase the power of the machine to at least 4 times that at present in use, and for distance work, *i.e.* at 6 ft., proportionately more power would be required. This problem should readily be solved by the electrical engineer, it being merely a matter of calculation and, possibly, experimental work to produce the apparatus satisfactorily. It would be of great value to radiologists if a standard method for the production of high-tension currents could be evolved. Whether it should be produced by the coil or the high-tension transformer is a matter for the engineer. The value of single-impulse exposures is demonstrated in the radiography of children; in infants the detail of bone is excellent, chiefly because the rapidity of the exposure eliminates voluntary or involuntary movements on the part of the patient. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

998. *Chemistry of Gold at High Temperatures and Pressures.* **H. H. Morris.** (Am. Chem. Soc., J. 40. pp. 917–927, June, 1918.)—A description is given of a steel bomb, and of a furnace for heating the bomb, for work at high temperatures and pressures. Gold is soluble in auric chloride, acidified with hydrochloric acid at the boiling temperature, aurous chloride being produced. Pure gold hydroxide yields metallic gold at 322° when heated with water in the closed bomb; small quantities of inorganic salts, for example $MgCl_2$ and $NaCl$, lower this point of decomposition as much as 70 deg., although $CaCl_2$ has a slight tendency to prevent decomposition. Calcite when heated with gold chloride under pressure becomes plated with gold above 310°, and excellent gold crystals may be obtained as part of the plating. The reaction takes place in two stages, auric hydroxide being first produced and then reduced to the metal. Magnesite may be gold-plated in a similar way, but the crystals formed show a different habit from those produced on calcite. Gold chloride may be heated under the pressure of water-vapour as high as the critical temperature of water before the metallic gold separates; if, however, small amounts of $NaCl$, $MgCl_2$ or $CaCl_2$ are added, the solution becomes much more stable towards heat, only incipient reduction being obtained at 450°–460°. The stability of these solutions containing double chloride is also exhibited towards calcite and magnesite, which only become slightly plated with gold when heated to 500°. Calcium bicarbonate has no effect on the stability of gold chloride towards heat, whereas magnesium bicarbonate acts like the normal carbonate, giving gold hydroxide and metal at 322°. T. S. P.

999. *Inclusions in Steel and Ferrite Lines.* **J. E. Stead.** (Iron and Steel Inst., J. 97. pp. 287–292, 1918. Engineering, 105. pp. 559–562, May 17, 1918.)—Opinions have been divided as to whether or not non-metallic inclusions in steel induce the crystallisation of ferrite. The author, therefore, places on record a number of experiments carried out with a view to settling the question. Various non-metallic substances were mechanically inserted in various steels which were then submitted to prolonged thermal treatment at high temperatures and then forged. The only material which showed any signs of inducing ferrite segregation was fluorspar. It was not found possible to induce crystallisation of ferrite or cementite on the walls of mechanically produced cavities. Prolonged heating to 1200° C. of steels in which the phosphorus and iron are irregularly distributed caused diffusion of the phosphide, with the production of uniform material. The result is that such treatment caused ghost lines to disappear, but did not affect the distribution of the non-metallic inclusions. All the evidence, therefore, leads to the conclusion that non-metallic inclusions and cavities do not induce the crystallisation of ferrite, but that it is the phosphorus which leads to the formation of the so-called "ghosts." F. C. A. H. L.

1000. *Allotropy of Cadmium.* **E. Cohen.** (K. Akad. Amsterdam, Proc. 20. 8. pp. 1177–1185, 1918. Am. Chem. Soc., J. 40. pp. 1149–1156, Aug., 1918.)—A detailed criticism of the results published by Getman [see Abs. 206 (1918)] in which it is shown that various mistakes occurred in the assumptions made by Getman in his paper on the allotropy of cadmium. If these mistakes are corrected, Getman's results are shown to be identical with those of Cohen and Helderman, thus forming a welcome control of the work of the latter investigators. T. S. P.

1001. *On the Influence of Forging upon the Mechanical Properties of Steel.* **G. Charpy.** (Comptes Rendus, 167. pp. 12–14, July 1, 1918. Engineering, 106. pp. 310–314, Sept. 20, 1918.)—Hot-forging a steel is found to produce an increase in the reduction of area, in the bending angle in a shock test, and in the impact value, if the test-pieces are cut in a direction parallel to that of rolling. When, however, the samples are cut transversely to the direction of rolling, the values for these three properties are greatly lowered as the amount of forging is increased. The extent of the variation increases as the metal becomes less pure, segregated, or spongy. For gun-barrels, etc., in which resistance to transverse stresses is required, tests made on specimens cut longitudinally are of little value. F. C. T.

1002. *Metallography of Tungsten.* **Z. Jeffries.** (Am. Inst. Mining Eng., Bull. No. 138. pp. 1037–1092, June, 1918. Engineering, 106. pp. 239–242, Aug. 30, 269–275, Sept. 6, and pp. 300–302, Sept. 13, 1918.)—Gives an outline of the manufacture of wrought and ductile tungsten and compares the properties of the metal with those of the common ductile metals. The metallography of wrought and ductile tungsten in the various stages of manufacture is dealt with in detail and illustrated by means of a large number of photomicrographs.

The effect of change of temperature on the structure of tungsten ingots, and the changes of grain-size due to incomplete fusion are discussed.

The effect of time and temperature on the grain-size of tungsten, the structure and properties of tungsten filaments after use, and the most satisfactory methods of polishing and etching specimens are also dealt with.
C. O. B.

1003. *Grain Growth in Steel.* **H. M. Howe.** (Rev. de Mét. 15. pp. 137–172, March–April, 1918.)—The knowledge of the grain growth of metals increases at such a rate that the author considers it desirable to state the present position. Grain growth may be divided into two classes: (1) normal growth, which is slow even at high temperatures, and (2) rapid growth, which occurs when a previously plastically deformed metal is heated to some definite temperature. In the latter class growth follows the "principle of concurrence," according to which certain grains show a tendency to survive; the tendency being determined by such factors as superiority of dimensions, amount of deformation, temperature, and crystallographic stability. On heating, such grains increase in size by absorption of the more feeble ones, the rate of growth generally increasing with rise of temperature. According to Jeffries, grains suddenly acquire the power of growth at a certain definite temperature, which has been called the "germinative temperature." The rate of growth is greatly increased by the existence of temperature gradients and variations in the amounts of plastic deformation to which a specimen has been subjected in its various parts. The term "ferritiferous state" has been introduced to cover all forms of iron-carbon alloys in the unhardened state. At the moment of its formation, immediately above Ac3, austenite is produced in fine grains, and on reversal to the ferritiferous state the regenerated grains are of the same size as the austenite grains from which they are produced. This is the "principle of heredity" and forms the basis of the technical processes for grain-refinement. The principle is not limited to metals which undergo allotropic modification, but may apply during fusion and solidification. It also applies to very low-carbon steels, and there is a considerable amount of evidence of its applying to electrolytic iron. The influence of the thickness of the sheet in the growth of electrolytic iron is inexplicable. Surface tension also plays a part in determining grain-size, thus the perpendicularity of the frontiers of ferrite grains to the external surface and to the internal surfaces of cracks and fissures is a natural effect of surface tension. F. C. A. H. L.

1004. *On the Slow Contraction of Hardened Carbon Steels.* **T. Matsushita.** (Tôhoku Univ., Sci. Reports, 7. pp. 43–52, July, 1918. Seventeenth Report of the Alloys Research Inst.)—A study of the secular change of length of steel bars quenched from 800° and 900° C. shows that two distinct processes are operating. The first effect, which is chiefly noticeable in the lower-carbon steels and in the specimens quenched in oil, is a gradual elongation which is ascribed to the breakdown of the solid solution. The elongation-temperature curves of the steels quenched in oil show contraction due to the separation of cementite, with steps at 170° and 340° C. at which this separation is especially rapid. This process goes on even at room temperatures and accounts for the second effect observed, *i.e.* a secular contraction of the higher-carbon steels especially if quenched in water. The contraction can be artificially accelerated by heating the quenched material to 80° to 100° C. and hardened steels can be made practically unshrinkable without diminishing their hardness by heating them to 100° C. for 2 hours. Measurements of the electrical resistance of these steels at high temperatures confirm the conclusions drawn from the elongation measurements. The heat evolved after quenching was measured and found to be somewhat greater from a 0·94 % carbon steel quenched in water than from one containing 0·56 % carbon and quenched in oil. F. C. T.

1005. *On the Velocity of Oxidation of Nitric Oxide in Reference to the Industrial Problem of the Oxidation ("Recuperation") of the Oxides of Nitrogen.* **E. Briner.** (Archives des Sciences, 46. Supplement, pp. 23–25, July, 1918. Paper read before the Soc. de Physique de Genève.)—The author has commenced the study of the conditions affecting the oxidation of nitric oxide, formed in the arc discharge through air. In presence of excess of oxygen, the oxidation of nitric oxide is a bimolecular reaction, the velocity coefficient at 21·5° having a value of about 0·051. As regards the influence of temperature, this will vary according to the conditions of heat radiation, but under the particular conditions of the author's experiments, lowering the temperature by 10 deg. (between 6° and 50°) increases the oxidation by 10–20 %, due probably to the fact that lowering the temperature favours the production of N_2O_4 molecules (also N_2O_3). A. F.

1006. *The Sign of the Zinc Electrode.* **W. D. Bancroft.** (J. Phys. Chem. 22. pp. 373–379, May, 1918.)—During recent discussions by the American Electrochemical Society [see Abs. 1561 (1913) 718 (1918)] it has been urged by Lewis and others that, contrary to the common practice, the potential of zinc in its sulphate should be considered positive and not negative. The zinc terminal of the primary battery is marked minus because in the external circuit the positive current flows from the copper to the zinc, which brings the battery into line with the dynamo as a source of electric energy, and is in accordance with the rule that electricity flows from a place of higher potential to one of lower potential. This rule does not settle the problem, however, and physical chemists have changed their standpoint several times. The author considers that the difficulty vanishes when we say that the chemical potential of the zinc in the Daniell cell is higher than that of copper, but its electrical potential is less, the distinction between chemical and electrical potential having concisely been stated by Gibbs. With electrodes forming kathions the e.m.f. is a measure of the difference of the chemical potentials, but has the opposite sign; with electrodes forming anions the two potentials have the same sign. He would retain the minus sign for the zinc potential in agreement with the Bunsen and Faraday Societies. H. B.

1007. *Cuprous-Oxide Photochemical Cell.* **T. W. Case.** (Am. Electrochem. Soc., Trans. 31. pp. 351–364; Disc. 364, 1917.)—When copper formate is electrolysed between copper electrodes, cuprous oxide forms a red coating upon the anode. A similar coating, though thinner, is formed on simple immersion. Two coated plates immersed in copper formate form a photoelectric cell, which in sunlight is capable of giving 0·11 volt. The current density is about 50 microamps./cm.^{2}, and the current flows in the solution from the illuminated to the dark plate. The cell fatigues by oxidation of the cuprous oxide, but if each plate is exposed alternately, an alternating current is produced, making 120 cycles of illumination per sec. With powerful illumination, the author produced a loud musical note in an audion, and continued this for 500 hours without disintegration of the light-active material. E. E. F.

1008. *Influence of a Magnetic Field and of Mechanical Stirring on the P.D. of an Electrolytic Cell.* **T. Mashimo.** (Kyōtō Coll. Sci., Mem. 2. pp. 341–347, Oct. 1917.)—With Pt electrodes in a dilute solution of ferric chloride, the effect of a magnetic field (3000 to 6900 gauss) on the p.d. between the electrodes is especially noticeable when it is applied to the kathode. A diminution in the p.d. takes place, which diminution is less when a solution of a nickel or cobalt salt is used in place of the iron salt. With iron electrodes the effect is more complex. A weak magnetic field applied to the anode causes an increase in the p.d. between the electrodes, whereas when applied to the kathode it causes a diminution. With a stronger magnetic field (strength not given) diminution in the p.d. takes place no matter whether the field be applied to the anode or kathode. With a relatively strong current (no details given) in the battery circuit, the magnetic field, applied to either of the electrodes, causes a diminution in the p.d.; with a weak current a small increase in the p.d. is caused when the magnetic field is applied to the anode. With a weak current in the battery circuit the p.d. diminishes when the katholyte is stirred and increases when the anolyte is stirred. With a strong current in the battery circuit the effect of stirring is more noticeable at the kathode than at the anode. Mere stirring, without a battery in the circuit, of the electrolyte near one electrode gives rise to an e.m.f. between electrodes of the same metal immersed in the same solution; the e.m.f. produced and the direction of current flow depend on the nature of the metal solution used. T. S. P.

1009. *Corrosion of Metals by Acids.* **O. P. Watts** and **N. D. Whipple.** (Am. Electrochem. Soc., Trans. 32. pp. 257–280; Disc., 280–284, 1917.)—The corrosion tests were carried out in beakers containing 180–190 cm.^{3} of the acid or other corroding agent, the beakers being covered by watch-glasses to lessen evaporation, and set in a constant-temperature water bath. The square sheets of metal, with the exception of Au and Pt, were of such dimensions that they were held upright by the sides of the beakers, so that both sides of the sample were exposed to the corroding agent. The extent of corrosion was determined by weighing the sample before and after the test.

The hypothesis which has previously been put forward by one of the authors that the protective effect of arsenic on the corrosion of iron by sulphuric acid is due to polarisation by hydrogen, is confirmed by the fact that: (1) the corrosion by acids of iron protected by arsenic is invariably greatly stimulated by oxidising agents, and (2) arsenic does not protect iron from attack by corrosive agents which evolve no hydrogen by their action. Amalgamation protects zinc from corrosion by acids because the discharge potential of hydrogen on mercury exceeds the potential of zinc. Protection by arsenic and by amalgamation are alike in their nature. Tin and lead are only very slowly dissolved by non-oxidising acids, although their potentials are such as would cause their ready solution in acids, if it were not for the unusually high discharge potential of hydrogen on them. Removal of hydrogen by an oxidising agent causes these metals to dissolve readily in acids that otherwise corrode them very slightly. It is similarly shown that the corrosion by acids of metals below hydrogen in the potential series, namely copper and silver, can be brought about by the presence of oxidising agents. The oft-quoted statement that the corrosion of amalgamated zinc in dilute sulphuric acid is accelerated by reduction of the external pressure, is shown to be incorrect. The corrosion is actually decreased, reduction in pressure removing dissolved oxygen which ordinarily acts as a depolariser; a similar result holds for other metals.

As regards corrosion by acids metals may be classified as follows: (*a*) Metals whose potentials exceed the discharge potential of hydrogen on them; these dissolve readily in acids, except such as form insoluble salts. (*b*) Metals whose potentials are less than the discharge potential of hydrogen on them; these dissolve readily in acids only in the presence of oxidising agents. Au and Pt are not readily attacked by acids in general, even when these contain oxidising agents. The superiority of nitric acid over other acids as a general solvent for metals is due to its being at the same time an acid and an oxidising agent, it thus being enabled to dissolve metals of class (*b*), which non-oxidising acids cannot do. In dilute cyanide solutions gold belongs to class (*b*) and therefore oxygen is necessary for success in cyaniding gold ores. From measurements of the discharge potential of hydrogen in solutions of KCN and NaOH, and experiments on the corrosion of metals in NaOH, the authors conclude that the above statements will apply to the dissolving of any metal in any electrolyte from which it displaces hydrogen when passing into solution. It further follows that plating baths for depositing metals of class (*a*) cannot be strongly acidified without the deposition of much hydrogen in place of an equivalent amount of metal taking place, whereas a large proportion of acid may be added to solutions for the deposition of metals of class (*b*) without greatly lowering the current efficiency through the deposition of hydrogen. T. S. P.